14

A. Vanderpoorten

A bryological survey of the Brussels Capital Region
(Belgium)

Scripta Botanica Belgica ***14***

The
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BIBLIOTHEQUE DU JARDIN BOTANIQUE NATIONAL DE BELGIQUE
INV. N° 72863
BIBLIOTHEEK VAN DE NATIONALE PLANTENTUIN VAN BELGIË
B 74168

18 SEP. 1997

Meise
National Botanic Garden of Belgium

Scripta Botanica Belgica

Miscellaneous documentation
edited by the
National Botanic Garden of Belgium

Series editor: E. Robbrecht
Special editor of volume 14: H. Stieperaere

Volume 14

A. Vanderpoorten
A bryological survey of the Brussels Capital Region (Belgium)

This work has received the Emiel Van Rompaey award 1997.

CIP Royal Library Albert I, Brussels

A bryological survey of the Brussels Capital Region (Belgium)/ Alain Vanderpoorten — Meise: Ministry for SMEs and Agriculture, Directorate of Research and Development, National Botanic Garden of Belgium, 1997. — 83 p.; ill.; 22 cm. — (Scripta botanica Belgica; Vol. 14).

ISBN 90-72619-36-6
ISSN 0779-2387
Subjects: Botany

D/1997/0325/7

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Printed in Belgium by Universa, Wetteren

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Summaries

Summary. – An inventory of 99 IFBL squares of the Brussels Capital Region (Belgium), i.e. 55% of the 178 IFBL squares of the study area, is presented. In total 225 species were recorded. One species, *Ephemerum stellatum*, is new to Belgium, two species are new to the phytogeographical area of Brabant and 24 species are new to the Brussels Capital Region. The IFBL grid squares were grouped into five classes to enable the estimation of the specific regional frequency by calculation. The average of bryophytes km^{-2} is of 34.45 species but the floristic richness varies from less than 20 species km^{-2} to a maximum of 103 species km^{-2}. Fourty two species formerly recorded were not rediscovered recently, whereas 117 species (51% of the current bryoflora) have a frequency inferior to 5%. Urbanisation has definitely caused the disappearance of many habitats. The role of air pollution on the epiphytic bryoflora is more difficult to assess. The high concentrations of sulphur dioxide recorded during the 1960s and 1970s might have acidified the phorophytes, leading to an increase of acidiphilous species now rather common such as *Dicranum tauricum* and *D. montanum* that were not recorded in Brussels during the last century. On the other hand, the decrease of pollution by sulphur dioxide recorded over several decades could have allowed the reinvasion of some sensitive taxa as the Orthotrichaceae. Water quality is probably not a limiting factor for the aquatic bryoflora but the drying-up of the forests has caused an evident decrease of bog species and hygrophilous epiphytes. Some suggestions about the management of the environment for the conservation of the bryoflora are proposed.

Résumé. – *Etude bryologique de la Région de Bruxelles-Capitale (Belgique).* Un inventaire bryologique de 99 carrés IFBL de la région de Bruxelles-Capitale (Belgique), soit 55% des 178 carrés IFBL du secteur d'étude, est présenté. Un total de 225 espèces a été relevé. Une espèce, *Ephemerum stellatum*, est nouvelle pour la Belgique, deux le sont pour le district phytogéographique brabançon et 24 pour la région bruxelloise. Les carrés IFBL ont été groupés en cinq classes afin de pouvoir pondérer l'estimation de la fréquence régionale. Le nombre moyen estimé de bryophytes est de 34,45 espèces km^{-2} mais la richesse floristique varie de moins de 20 espèces km^{-2} à un maximum de 103 espèces km^{-2}. Quarante-deux espèces anciennement signalées n'ont pas été revues tandis que 117 espèces (51% de la bryoflore actuelle) ont une fréquence inférieure à 5%. L'urbanisation a certainement causé la disparition de nombreux habitats. Le rôle de la pollution atmosphérique dans la distribution de la bryoflore épiphyte est plus

difficile à estimer. Les pics de pollution pour le dioxyde de soufre enregistrés dans les années 1960-1970 pourraient avoir acidifié les phorophytes et provoqué l'augmentation des populations d'espèces maintenant assez fréquentes comme *Dicranum tauricum* et *D. montanum* non signalées de Bruxelles au siècle dernier, la baisse des concentrations en dioxide de soufre enregistrée depuis quelques décennies pourrait en revanche avoir permis le retour de certains taxons sensibles comme les Orthotrichaceae. La qualité de l'eau ne semble pas limitante pour la bryoflore aquatique, mais l'assèchement des massifs forestiers est à la base de la régression spectaculaire des espèces paludicoles et des épiphytes hygrophiles. En conséquence certaines suggestions concernant une gestion de l'environnement pour la conservation de la flore bryophytique sont proposées.

Samenvatting. — *Een bryologische studie van het Brussels Hoofdstedelijk Gewest (België).* De blad- en levermossen van 99 IFBL-kilometerhokken van het Brussels Hoofdstedelijk gewest, 55% van de 178 km-hokken, werden geïnventariseerd. Er werden 225 soorten aangetroffen. Eén soort, *Ephemerum stellatum*, is nieuw voor België, twee soorten zijn nieuw voor het Brabants district en 24 soorten zijn nieuw voor het Brussels Hoofdstedelijk Gewest. De km-hokken werden gegroepeerd in vijf klassen om een schatting van de regionale zeldzaamheid mogelijk te maken. Het gemiddeld aantal bryofyten km^{-2} bedraagt 34,45 soorten, maar de floristische rijkdom varieert van 20 tot 103 soorten km^{-2}. Tweeënveertig soorten werden niet meer teruggevonden en 117 soorten hebben een lagere frequentie dan 5%. Urbanisatie veroorzaakte zeker de verdwijning van veel habitaten. De invloed van de luchtvervuiling is veel moeilijker te beoordelen. Enerzijds kunnen de zeer hoge zwaveldioxide-concentraties tussen 1960 en 1970 de boomschors verzuurd hebben, met een uitbreiding van zuurteminnende soorten zoals *Dicranum tauricum* en *D. montanum* tot gevolg. Deze soorten waren in de vorige eeuw in het Brusselse niet gekend. Anderzijds kan de afname van de zwaveldioxide-vervuiling sinds de laatste decennia de terugkeer van sommige gevoelige soorten, zoals de Orthotrichaceae, toegelaten hebben. Waterkwaliteit lijkt geen groot probleem, maar de verdroging van de bosmassieven veroorzaakte een spectaculaire achteruitgang van de moerasmossen en de vochtminnende epifyten. Tenslotte worden een aantal maatregelen voorgesteld om de mosflora beter te beschermen.

1

Introduction

In the course of a phytosociological survey of the acidic grasslands of Brabant (Vanderpoorten 1994), unexpected species such as *Diplophyllum obtusifolium, Scapania curta* and *Lophozia bicrenata* were collected in the southern suburban area of Brussels. At that time a review of the literature concerning the collections had revealed only old publications with some lists of species (Delogne & Durand 1883, Demaret 1937), isolated observations of species (De Zuttere 1976, Vanden Berghen 1955-1957, Heinemann & Vanden Berghen 1943), or mention of common species (Gérard 1978), but no synopsis and especially no recent publications on the bryoflora of Brussels were found. It was then decided to extend the study to the whole city of Brussels. This area was defined as the Brussels-Capital Region, that provided within its 19 communes easy limits for a study area. As the Brussels-Capital Region is a rather large study area, it was decided to make a selection of squares of 1 km^2, mainly in areas with the least human influence. About 55% of the IFBL grid-squares of 1 km^2 were selected. The results of this prospection are given here. They allow an assessment and the localisation of the bryological richness of Brussels, as well as an evaluation of the evolution of the bryoflora and its relations with water and air quality.

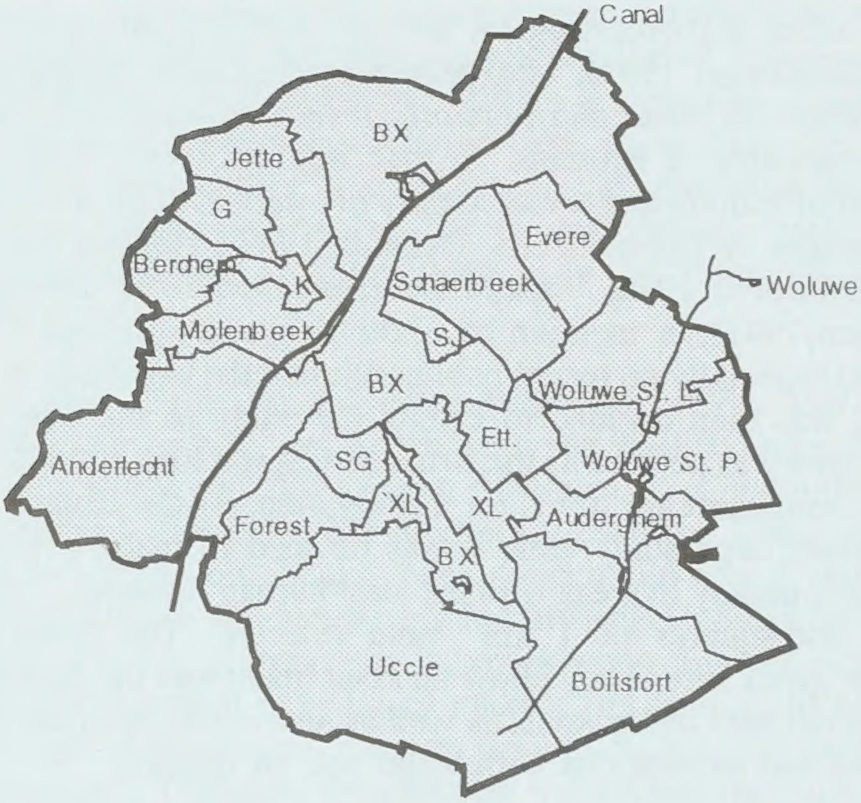


Figure 1
Study area and its communes. BX, Bruxelles; G, Ganshoren; K, Koekelberg; SG, Saint-Gilles; SJ, Saint-Josse; XL, Ixelles; Ett., Etterbeek. 'Canal' = canal Brussels-Antwerp; 'Woluwe' = the rivulet Woluwe.

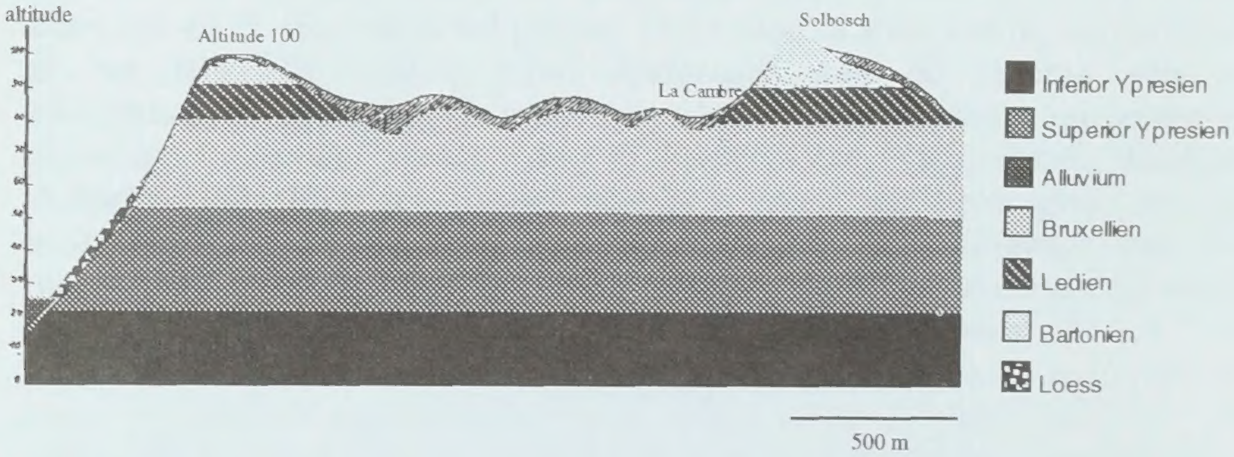


Figure 2
Diagram of the geological layers (redrawn from Camerman 1955)

2

Study area

The 19 communes of the Brussels-Capital Region cover 161.6 km^2 in the centre of Belgium (Gourou 1969) (fig. 1). The underlying geology of the area is dominated by a subhorizontal layer of sands belonging to the Tertiary, including the typical Bruxellien with its rough, calcareous yellowish to reddish sands and calcareous sandstone. The younger layers include calcareous sandstone of the Lédien, sands of Wemmel and clays of Assche both belonging to the Bartonien (fig. 2). These layers were covered by loess during the interglaciary periods of the Quaternary. The upper part of the layer was decalcified and its depth varies between some centimetres to one or more metres. During the Pleistocene, erosion of the upper loose layers to the Primary layer has brought to light the peneplain in the valleys. The resulting differences of level between the peneplain and the tops of the hills, mostly constituted by the sands of the Bruxellien, form a lithostructural abrupt. The slopes can be rather steep, e.g. at the law-courts, at Altitude 100 or at the park of Rodebeek, where the gradients can be superior to 9%, hence the frequency of the word mountain (the Kauwberg in Uccle, the Montagne aux herbes potagères in Schaerbeek) in the local toponimy (Danckaert 1979). Thus the sandy layers appear very rarely in quarries or in the famous ravines whose origin has been much discussed. The most probable explanation is that the loamy layer locally crept along the gradient, causing above a hollow quickly enlarged by rainfall. These consequently flow in a direction perpendicular to the gradient and erode the visible sandy layer (Devadder et al. 1928).

The hydrographic network is mostly located on the tertiary layers. It is fed by the Bruxellien and the Yprésien water tables, that are very close to the surface in almost half the area. These waters are highly mineralised with a high pH: ca. 7.8 in the rivulet Woluwe and ca. 7.3 with 65.6 mg/l of Ca^{++} in the water table under the forest of Soignes (Inst. Brux. Gest. Env. 1994b). Chemical analysis demonstrated the good quality of waters from the water table, that do not need to be purified before consumption (Inst. Brux. Gest. Env. 1994b) and that were classified in category 1a of the EEC directive 75/440 (Journ. Off. Comm. Eur. 1975), i.e. mean annual concentration of $NH_4^+ < 0.05$ mg/l and of $P_2O_5 < 0.4$ mg/l. The main river of the area is the Senne. This small and very slow river is paradoxically characterised by its very large valley 1600 to 1800 metres wide. This river was able to flood very quickly its floodplain in the past and caused much damage. The situation was worse for the tributaries due to the stiffness of the slopes. Moreover the construction of roads prevented the infiltration of water in the soil after rainfalls, and the ponds along the streams, constituting real natural overflows, were progressively destroyed (Danckaert 1979). Most of the hydrographic network has thus been canalized and the former alluvial meadows as at the Bempt in Forest disappeared (Meganck 1974).

At the beginning of the XIXth century, Brussels was restricted to the ca. 40 km^2 of the current centre. Behind the city's ramparts, the outlying parts were constituted of small woods, but especially of fields and gardens on the highly fertile soils (Jacowick 1812). Between 1830 and 1860, the agricultural fields separating the villages such as Molenbeek from the city disappeared and the population of districts such as Ixelles or Molenbeek quadrupled. But the outer parts of the current agglomeration as Anderlecht remained small market-towns where places as Cureghem were described as wet meadows (Jacquemyns 1936). After the second world war, the increase of built-up areas has caused the disappearance of the last rural areas within the Region, e.g. the heath of the Kersbeekbosch or the grasslands in Forest (Meganck 1974). The decrease of the rural areas in the suburb is more recent; there was for example still a shepherd in Evere in 1960 (Danckaert 1979). Anderlecht remains currently the only commune that has conserved some rural areas, probably because the progression of the city is asymmetric to the North, the East and the South East (Leblicq & De Metsenaere 1979).

Brussels can thus be understood currently as the succession of four concentric areas: a central area with important commercial and administrative activities, a dense surrounding district mostly built during the last century, a peripheral area less built-up, and a suburb.

In the South, the forest of Soignes is the limit for the development of the city. A hunting ground of the dukes of Brabant during a millenary, this forest was replanted with beeches during the XVIII th. century under the Austrian government (Galoux 1959) and was sold in 1822 to the Dutch General Society that exploited about 2/3 of the surface. The 4380 remaining hectares were repurchased in 1842 by Leopold I and became a national forest (Vleminck 1958). The potential vegetation of this forest is very diversified and includes mesophilous, thermophilous, acidophilous and wet oakwoods and ashwoods (Delvosalle & Vanden Berghen 1959). Due to its geographical position this forest is subjected to the pressure of an increasing public, especially in places as the Rouge-Cloître, an ancient abbey surrounded by ponds and springs. The management plan of the forest includes the delimitation of nature reserves and protected areas but also the putting of calcareous gravel on paths to facilitate the circulation of people.

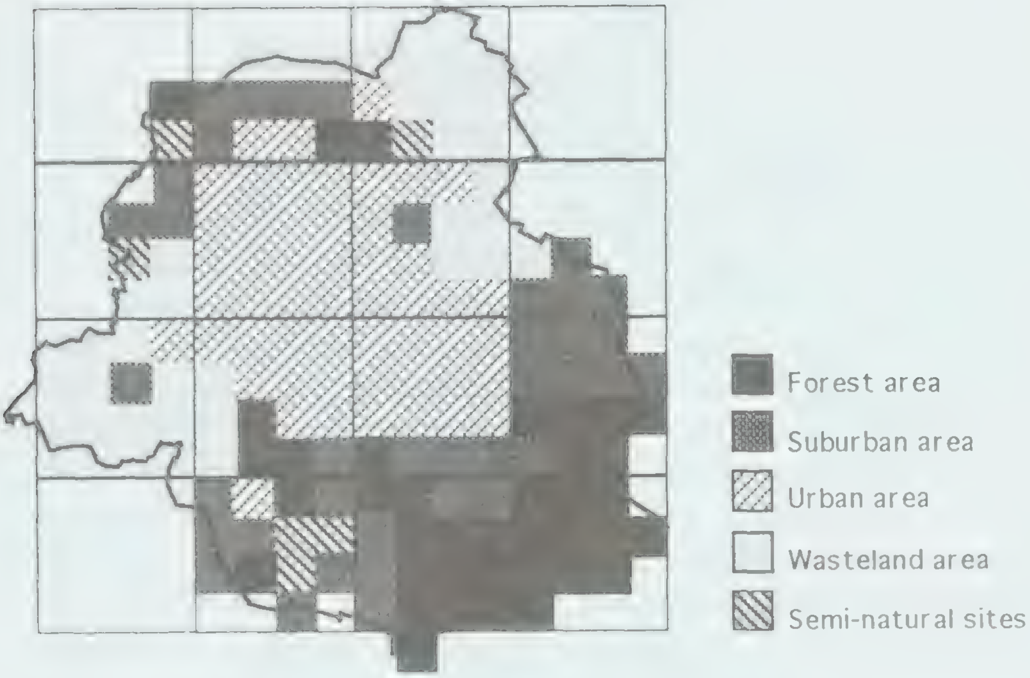


Figure 3. Distribution of the classes of habitats.

Thirty eight percent of the forest belong to the Brussels Capital Region so that about 50% of the surface of the city can be currently qualified as green area (Inst. brux. Gest. Env. 1994b) including the nature reserves on 29 ha outside the forest, the parks and several places such as railway slopes.

Due to this heterogeneity, Brussels was divided into five areas supposed to differ in their bryoflora (fig. 3). The forest area includes the forest of Soignes, the Laerbeek and some ancient parks derived from the forest as the Duden park, the Wolwendael, where natural or semi-natural areas still exist partly thanks to their ancient status of private property (Kempeneers 1978). The forest soil is mostly composed of loess but locally sands appear in the ravines. The semi-natural sites include nature reserves such as the marshes of Jette-Ganshoren or green areas such as the Kauwberg that are at least partly managed for nature conservation. The wasteland area includes both agricultural areas and industrial wasteland on loamy to clayey soils. Lastly the suburban area includes scattered buildings and green areas whereas the urban area is characterised by a high density of buildings. Both have a very disturbed soil.

Table 1
Classes of rarity based on the estimated relative frequency

Class of rarity	Limits of the class
CC	>50%
C	25-50%
AC	10-25%
AR	5-10%
R	1-5%
RR	<1%

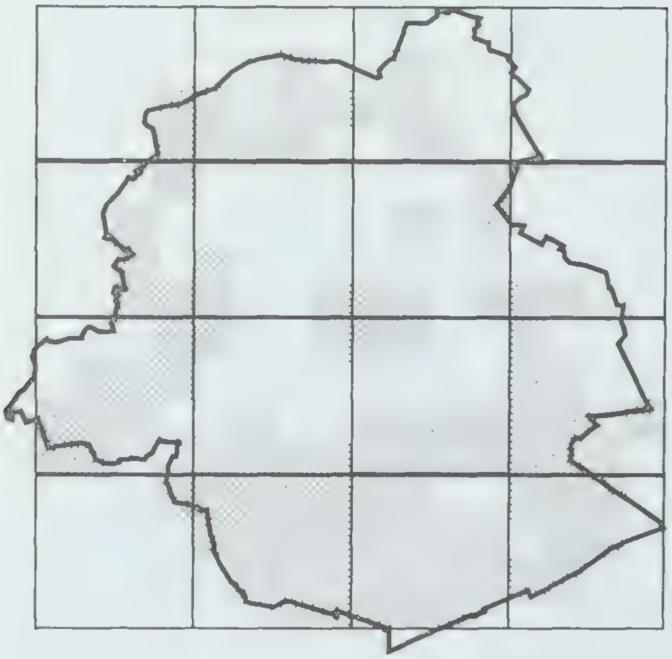


Figure 4. Distribution of the selected squares.

3

Methods

3.1 Sampling for the floristic inventory

The 1 km^2 IFBL grid (Van Rompaey & Delvosalle 1978) was used for the inventory. Some of the peripheral squares are only partially included within the official limits of the Region; that is why the study area, with 178 squares, is larger than the Region sensu stricto. Ninety nine easily accessible squares representing about 55% of the study area were selected (fig. 4); that is why the park of the royal palace in Laeken or the domain of the NATO were not visited and the central area was less intensively prospected. Each square was prospected at least twice during the period 1993-1996. Critical or interesting taxa were systematically collected; specimens are conserved in the herbarium of the National Botanic Garden of Belgium (BR).

These observations were completed with data from recent publications (De Zuttere & Sotiaux 1992a, Arts & Hoffmann 1996) and unpublished observations by A. Sotiaux for the period 1980-1983. The data of literature published before 1980 (Delogne & Durand 1883, Demaret 1937, De Zuttere 1976, Vanden Berghen 1955-1957, Heinemann & Vanden Berghen 1944, Gérard 1978) were checked.

3.2 Nomenclature

The nomenclature follows Grolle (1983) for liverworts except for the genera *Chiloscyphus* (Smith 1992) and *Marchantia* (Bischler-Causse 1993, Bischler-Causse & Boisselier-Dubayle 1991). The collection of *S. curta* from the Kauwberg was first considered to belong to *S. scandica* (det. P. De Zuttere, see also De Zuttere & Sotiaux 1992b), mainly because of relatively ill defined trigones at the border of the leaf margins. However, the leaves show a clear border with thickened walls so that the collection rather belongs to *S. curta* (H. Stieperaere & A. Sotiaux, pers. comm.)

The nomenclature for the mosses follows Corley et al. (1981) and Corley & Crundwell (1991) with some exceptions. Touw & Rubers (1989) are here followed in accepting the reduction of *Plagiothecium succulentum* to synonymy of *P. nemorale* because the main difference between the two taxa, i.e. the length of the lamina cells, intergrades. The distinction of *Fissidens bambergeri* from *F. viridulus*, based on the very characteristic incomplete border of the apical and dorsal laminae of the former species (Demaret & Castagne 1959), is accepted. De Sloover & Demaret (1968) were also followed in distinguishing *Ephemerum minutissimum* from *E. serratum* because both taxa are morphologically and ecologically characterized. Some infraspecific taxa of doubtful value (*Pohlia nutans* f. *decipiens* in Wilczek & Demaret, 1971) or critical aggregates (*Hypnum cupressiforme* var. *lacunosum*, *Hypnum andoi*) (Smith 1995) were all included in the species they belong to. A collection of *Bryum* with green gemmae 150-200 µm long having teeth-like primordia up to 1/3 of the length of the gemmae and many per leaf axil, with yellowish-brown papillose rhizoids and a conspicuously excurrent nerve (200-250 µm) – almost a hair-point when dry –, was considered by T. Arts (pers. comm.) as a form with excurrent nerve of *Bryum gemmiferum*. The plants were also sent to A.J.E. Smith who found bulbils up to 850 µm long having large leaf primordia from about the middle and who determined *B. dunense* because of the colour, the size and the length of the primordia of the bulbils and the excurrence of the midrib of the leaves. This emphasizes once more that the variability of the species belonging to the *Bryum bicolor* complex should be evaluated by further research (Corley et al. 1981). Indeed the degree of variation of species such as *Bryum gemmiferum* or *B. barnesii* is not well if at all described in Flora of the Belgian bryophytes (Demaret 1993) where *Bryum dunense* is not at all mentioned whereas it is said to occur in Belgium (Smith 1978). Pending further studies it was decided to exclude *Bryum dunense* from the list and the maps. Lastly, the conceptions of Crum & Anderson (1981) about *Tortula pagorum* were followed. In fact, the specimens collected in Brussels match exactly their description of the species: very small plants 2-5 mm high, bearing ecostate and very papillose leaf-like gemmae in axil of the upper leaves. Moreover, the plants were collected at the base of roadside trees which is precisely the ecology given for this species. Following this treatment *T. pagorum* is rather distinctive from the several forms of *T. laevipila*, even from those bearing gemmae, but a serious assessment of these taxa would be definitely necessary in Belgium.

3.3 Estimation of frequencies

Sampling was not done randomly. The relative frequency of taxa, calculated on the 99 selected squares, cannot be simply extended to the whole area because this would cause an overestimation of frequencies. The estimation of the absolute frequency of each taxon in each ecological area was therefore calculated by multiplication of its observed absolute frequency by the number of prospected squares of the class divided by the total number of squares of the class: 1.25 in forest area, 1 in semi-natural sites, 3 in waste lands, 1.4 in suburban areas, 3.11 in urban areas. For a taxon, the sum of these estimated frequencies for all the habitat classes gives a more realistic estimation of its frequency in the whole area:

$$\text{F.th.} = \sum_{i=1}^{5} \text{F.obs.}(A_i) \times k_i$$

where F.th. is the absolute estimated frequency of the taxon in the 178 km^2 of the area, F. obs. is the real observed frequency of the taxon in class i, and k is the constant of correction for class i.
The relative frequency expected for a taxon is consequently:

$$\text{f.th.} = \text{F.th.}/\ 178$$

For each taxon, the rarity class was established according to the estimated relative frequency (tab. 1). The chosen system is closer to the logarithmic scale of rarity proposed by Stieperaere & Fransen (1982) and Schumacker (1985) than to the arithmetic scale used by Godefroid (1996) for the vascular flora of Brussels. It is more precise for the groups of endangered or threatened species with the highest extinction risks whereas it groups in broad classes the common or very common species. As the scale proposed by Benkert et al. (1995), it can be used to assess precisely the degree of threat to the rarest taxa in an attempt of conservation and of specific management of their particular habitats.

The area of Brussels was more intensively bryologically prospected (about 55% of the area) than Belgium and neighbouring areas (about 40%) and theoretical frequencies were estimated for the whole Region. Nevertheless, the classes of rare species are less restrictive than those proposed by Schumacker (1985) for the mapping of the Belgian liverworts.

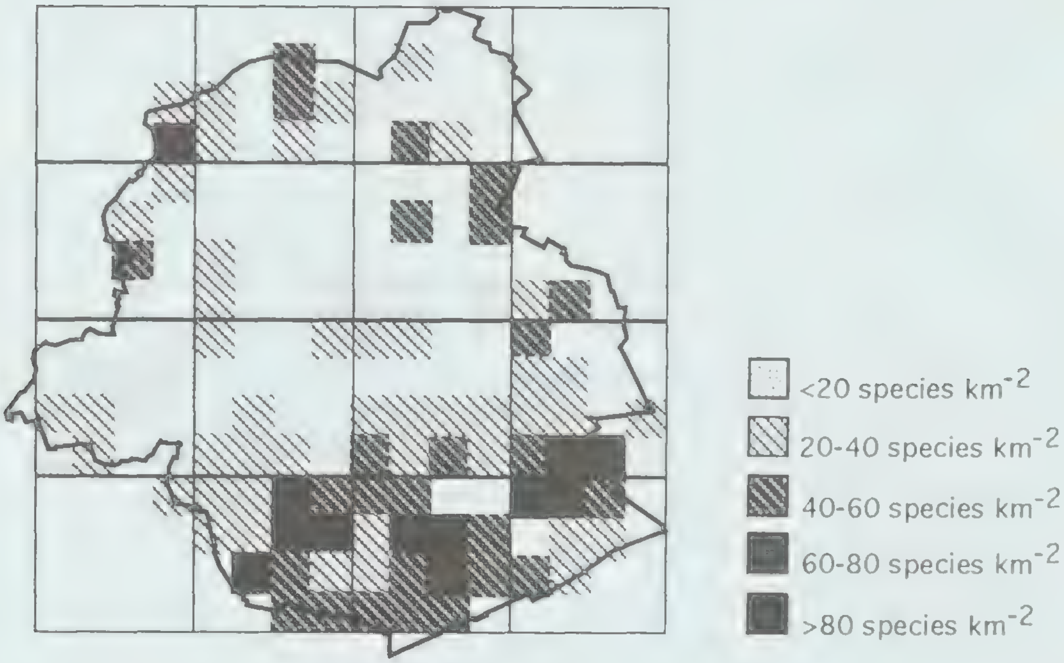


Figure 5. Distribution of the bryophytic richness per km^2.

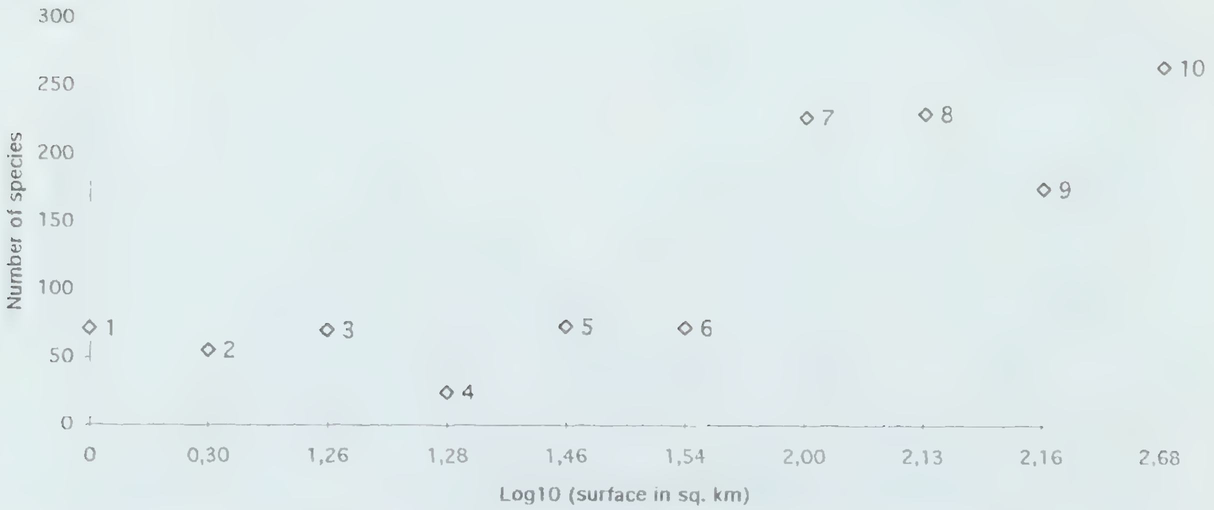


Figure 6. Comparison of the specific richness per km^2 between several European cities.
1 Camerino (Cortini Pedrotti 1989), 2 Segovia (Lara et al. 1995), 3 Catania (Lo Giudice 1992), 4 Brussels centre (present study), 5 Rome (Carcano 1989); 6 Szczecin (Fudali 1994), 7 Brussels (present study), 8 Regensburg (Durrhämmer 1995), 9 Halle (Müller 1993), 10 Berlin (Schaepe 1986).

4

Results

4.1 Evaluation of the floristic richness

The bryoflora of the Brussels Capital Region includes 267 species according to the present inventory and literature. This number takes into account that some of these data were incorrect or of doubtful value after checking of the material of BR. *Nardia geoscyphus*, recorded by Heinemann & Vanden Berghen in 1944, is not known in Brabant according to Schumacker (1985). *Grimmia orbicularis*, recorded by Delogne & Durand (1883), is not confirmed by a sample at BR. *Rhynchostegium rotundifolium*, that appears on the list of Delogne & Durand (1883), is considered by Demaret & Lambinon (1969) as very doubtful. The sample of *Philonotis rigida* of Delogne & Durand (1883) was not found at BR and all Belgian specimens recorded as *P. rigida* belong in reality to *P. arnellii* (Raeymaekers 1981). The data concerning *Dicranum majus* (Demaret 1937) are incorrect because the only sample at BR is in fact a robust form of *D. scoparium*. Lastly, Arts (1989) demonstrated that the record of *Gymnostomum calcareum* was based on a wrongly identified collection of *Leptobarbula berica*.

The list of the 40 hepatics and 185 mosses recorded since 1980 in Brussels is given in table 2. The list includes one species new to Belgium, *Ephemerum stellatum*, discussed in more detail in Vanderpoorten et al. (1996). Two species are new to the phytogeographical district of Brabant, 24 to the Brussels Capital Region (table 3).

The list of probably lost taxa is given in table 4. Some of them, e.g. *Targionia hypophylla*, were not seen in Belgium for a long time. Paradoxically they did not seem to have been very rare during the XIXth century according to the material at BR. Others, e.g. *Leucodon sciuroides*, were formerly qualified as rather frequent in the forest of Soignes (Heinemann & Vanden Berghen 1944). The local extinction of taxa has seldom been counterbalanced by the appearance and spread, as elsewhere in Belgium, of *Dicranum tauricum*, *Campylopus introflexus*, *Orthodontium lineare* (De Zuttere & Schumacker 1980, Stieperaere & Jacques 1995), and *Lophocolea semiteres*. This hepatic coming from the south hemisphere recently appeared in Belgium (Stieperaere 1994) where it is still very local. Its populations in Brussels represent a transition between the two areas of the presently known distribution of the species in the country: a single female population in the south of Brabant, both numerous male and female populations in the north (Stieperaere & Jacques 1995). This species is still rare in Brussels (map 20).

Table 2
Assessment of the specific frequencies
Z1, forest
Z2, semi-natural sites
Z3, wastelands
Z4, suburban area
Z5, urban area

Currently absent in the forest of Soignes, it is only present in disturbed sites under strong human pressure (road sides, cemeteries…) where people seem to play a very important role in the dispersion of the diaspores. In Belgium, the species was mainly known in sandy habitats, but it displays a much greater ability to colonize other biotopes in Brussels. It is for example able to grow on damp compacted loam, together with *Eurhynchium praelongum*. Very abundant in its localities, it is consequently very capable of quickly invading the whole area.

4.2 Distribution of the floristic richness

The estimated average species richness is of 34.45 species km^{-2}, but the distribution of the floristic richness is not homogeneous (fig. 5) and varies between less than 20 taxa km^{-2} to 103 taxa km^{-2}. To test whether the five zones of habitats differ in species richness, an ANOVA was applied to the species richness per km^{2} and showed significant differences between the means for $\alpha = 5\%$. A Student t test for populations with significant differences of variances for $\alpha = 5\%$ was therefore performed (table 5). It confirmed the heterogeneity of the distribution of the quantitative richness of the bryoflora. Rich squares with more than 60 species km^{-2} occupy obviously the south of the area. This part of the Region includes in fact the largest forest of the area, locally characterised by a combination of species including *Calypogeia muelleriana, Campylopus flexuosus, C. pyriformis, Dicranum montanum, Dicranodontium denudatum, Leucobryum glaucum* and *Plagiothecium undulatum* (maps 5, 77, 79, 95, 93, 144 and 174). Some places in the forest, as the Rouge-Cloître, the Trois Fontaines, the valley of the Vuilbeek and the ponds of the Enfants Noyés are especially noteworthy for the richness of their bryoflora because of the presence of habitats such as calcareous slopes with characteristic species including *Plagiochila porelloides, Encalypta streptocarpa, Plagiothecium cavifolium* (maps 30, 109, 170), and ash-willow woods including old elders on which epiphytes such as *Orthotrichum obtusifolium* (map 155) and *Cryphaea heteromalla* (map 85) can be found. Moreover the southern part of Brussels includes ancient quarries of sand such as the Kauwberg with silicicolous species including *Diplophyllum obtusifolium, Gymnocolea inflata, Lophozia bicrenata, Pogonatum nanum* and *Pohlia annotina* (maps 11, 14, 21, 180, 181). Only

	Observed frequencies					Estimated relative frequency	Class of rarity
	Z1	Z2	Z3	Z4	Z5		
Liverworts							
Aneura pinguis	5	1				4	R
Blasia pusilla	1					<1	RR
Calypogeia azurea	1					<1	RR
Calypogeia fissa	13	2			1	12	AC
Calypogeia muelleriana	14					10	AC
Cephalozia bicuspidata	21	2				16	AC
Cephaloziella divaricata	13	3	2	1		15	AC
Chiloscyphus polyanthos	3	1				<5	R
Conocephalum conicum	12	1	1	7		16	AC
Diplophyllum albicans	13	1				10	AC
Diplophyllum obtusifolium		1				<1	RR
Fossombronia wondraczeckii	1					<1	RR
Frullania dilatata	1					<1	RR
Gymnocolea inflata		1				<1	RR
Jungermannia gracillima	3	1				<5	R
Lejeunea ulicina	1					<1	RR
Lepidozia reptans	13			1		10	AC
Lophocolea bidentata	16	5		7		19	AC
Lophocolea heterophylla	35	7	2	17	4	52	CC
Lophocolea semiteres	2		2			<5	R
Lophozia bicrenata		1				<1	RR
Lunularia cruciata	27	6	4	16	5	50	CC
Marchantia polymorpha var. *polymorpha*		2				<5	R
Marchantia polymorpha var. *ruderalis*	4	3	2	1	1	10	AC
Metzgeria furcata	5	1				4	R
Nardia scalaris	1					<1	RR
Pellia endiviifolia	11	6		6		16	AC
Pellia epiphylla	29	2		4		25	C
Plagiochila asplenioides	1					<1	RR
Plagiochila porelloides	3					<5	R
Porella platyphylla	3					<5	R
Ptilidium pulcherrimum	1					<1	RR
Radula complanata	2					<5	R
Riccia bifurca	1		3	1		7	AR
Riccia fluitans	3					<5	R
Riccia glauca			1			<1	RR
Riccia sorocarpa	1	2	3	3	1	11	AC
Riccia subbifurca	1					<1	RR
Scapania curta		1				<1	RR
Scapania irrigua	1					<1	RR
Scapania nemorea	2					<5	R

	observed frequencies					estimated relative frequency	class of rarity
	Z1	Z2	Z3	Z4	Z5		
Mosses							
Acaulon muticum			1			<1	RR
Aloina aloides		1		1		<5	R
Aloina ambigua	5	6	2	2	2	15	AC
Amblystegium riparium	13	6	5	13	10	48	C
Amblystegium serpens	38	7	16	20	14	97	CC
Amblystegium tenax	1					<1	RR
Amblystegium varium	1					<1	RR
Anomodon viticulosus	2			1		<5	R
Aphanorhegma patens	3	1	2	1		7	AR
Atrichum undulatum	32	7	8	19	5	63	CC
Aulacomnium androgynum	7	1	2	2		10	AC
Barbula convoluta	37	9	16	24	18	100	CC
Barbula unguiculata	37	9	16	24	18	100	CC
Brachythecium albicans	2	5	4	4	2	18	AC
Brachythecium glareosum	9	1				7	AR
Brachythecium mildeanum		1				<1	RR
Brachythecium populeum	4	1	1	3	1	9	AR
Brachythecium rivulare	11	4	1	10		19	AC
Brachythecium rutabulum	37	9	16	24	18	100	CC
Brachythecium salebrosum	9	1				7	AR
Brachythecium velutinum	6	3	3	5	0	15	AC
Bryoerythrophyllum recurvirostrum	21	2	1	8	5	32	C
Bryum argenteum	37	9	16	24	18	100	CC
Bryum barnesii	1		1		3	8	AR
Bryum bicolor	1	2	2	2	5	16	AC
Bryum caespiticium	2	5	1	7	3	16	AC
Bryum capillare	20	6	11	17	8	63	CC
Bryum gemmiferum	11	6	6	8	9	43	C
Bryum klinggraeffii			1		2	<5	R
Bryum pseudotriquetrum					1	<1	RR
Bryum radiculosum	1	1	1		1	<5	R
Bryum rubens	1	3	3	2	1	11	AC
Bryum ruderale	2	3				<5	R
Bryum subapiculatum	3	1	4	3	4	19	AC
Calliergonella cuspidata	23	9	5	10	8	50	CC
Campylium chrysophyllum	1					<1	RR
Campylopus flexuosus	8					6	AR
Campylopus introflexus	17	1				12	AC
Campylopus pyriformis	9					6	AR
Ceratodon purpureus	37	9	16	24	18	100	CC
Cinclidotus fontinaloides		1				<1	RR
Cirriphyllum piliferum	2			3		4	R
Climacium dendroides				1		<1	RR
Cratoneuron filicinum	23	6		11	2	31	C

	observed frequencies					estimated relative frequency	class of rarity
	Z1	Z2	Z3	Z4	Z5		
Cryphaea heteromalla	3			1		<5	R
Ctenidium molluscum	2					<5	R
Dichodontium pellucidum	2					<5	R
Dicranella heteromalla	35	6	8	16	6	64	CC
Dicranella rufescens	3					<5	R
Dicranella schreberiana	2	3	1		1	[illegible]	AR
Dicranella staphylina	2	3		1		4	R
Dicranella varia	11	5	8	5	4	34	C
Dicranodontium denudatum	3					<5	R
Dicranoweisia cirrata	25	5	8	14	11	64	CC
Dicranum montanum	13			1		9	AR
Dicranum scoparium	16	3		2	1	16	AC
Dicranum tauricum	25	1		5	1	24	AC
Didymodon fallax	13	1	2	5	3	22	AC
Didymodon insulanus	2	1				<5	R
Didymodon luridus	4	1	1		4	13	AC
Didymodon rigidulus	3	2	1	4	2	11	AC
Didymodon sinuosus	4	1				3	R
Didymodon spadiceus				1		<1	RR
Didymodon tophaceus	1	2	1			<5	R
Didymodon vinealis	1	1	2	2	1	8	AR
Ditrichum cylindricum	7	1	2	2		11	AC
Ditrichum heteromallum	7					5	AR
Drepanocladus aduncus	1					<1	RR
Encalypta streptocarpa	8			1		6	AR
Ephemerum minutissimum	1					<1	RR
Ephemerum stellatum	1					<1	RR
Eucladium verticillatum	3					<5	R
Eurhynchium crassinervium	6	2		4	4	15	AC
Eurhynchium hians	18	9	4	12	3	39	C
Eurhynchium praelongum	33	8	11	23	10	81	CC
Eurhynchium pumilum	6	4	3	5	1	17	AC
Eurhynchium schleicheri	2	1	2	3	1	9	AR
Eurhynchium striatum	5	1				3	R
Fissidens bambergeri	1		1	1		<5	R
Fissidens bryoides	29	5	6	20	3	54	CC
Fissidens crassipes	3	1		3	2	7	AR
Fissidens dubius	1					<1	RR
Fissidens exilis			1			<1	RR
Fissidens gracilifolius	10		1	1		9	AR
Fissidens incurvus	2					<5	R
Fissidens pusillus	1					<1	RR
Fissidens taxifolius	22	6	5	16	2	43	C
Fissidens viridulus	3	1				<5	R
Funaria hygrometrica	16	4	12	10	12	58	CC

	observed frequencies Z1	Z2	Z3	Z4	Z5	estimated relative frequency	class of rarity
Grimmia pulvinata	30	9	24	16	18	100	CC
Gyroweisia tenuis	3					<5	R
Herzogiella seligeri	2					<5	R
Homalia trichomanoides	3		1	1		5	AR
Homalothecium lutescens	3	2				3	R
Homalothecium sericeum	12	7	3	11	7	38	C
Hygrohypnum luridum	2	1				<5	R
Hypnum cupressiforme	34	9	10	24	14	89	CC
Hypnum jutlandicum	12					8	AR
Hypnum lindbergii	1					<1	RR
Isothecium alopecuroides	1	1				<5	R
Isothecium myosuroides	8				1	7	AR
Leptobryum pyriforme		2	1			<5	R
Leskea polycarpa	1					<1	RR
Leucobryum glaucum	13					9	AR
Mnium hornum	36	6	2	13	5	55	CC
Mnium marginatum	1					<1	RR
Mnium stellare	4					<5	R
Neckera complanata	3			1	2	6	AR
Orthodontium lineare	8					6	AR
Orthotrichum affine	16	5	5	13	6	43	C
Orthotrichum anomalum	11	3	1	7	10	44	C
Orthotrichum cupulatum	1		2			<5	R
Orthotrichum diaphanum	21	8	13	26	19	94	CC
Orthotrichum lyellii	2			1		<5	R
Orthotrichum obtusifolium	1					<1	RR
Orthotrichum pallens	1					<1	RR
Orthotrichum pulchellum	2	1				<5	R
Orthotrichum pumilum		1		1		<5	R
Orthotrichum stramineum		1		1		<5	R
Orthotrichum striatum			1			<5	R
Orthotrichum tenellum	1	2		2		3	R
Phascum cuspidatum	5	4	7	7	3	28	C
Philonotis fontana			1			<1	RR
Physcomitrium pyriforme		3	1			<5	R
Plagiomnium affine	15	3	3	8	3	29	C
Plagiomnium cuspidatum	1		2	1	1	7	AR
Plagiomnium ellipticum	1					<1	RR
Plagiomnium rostratum	9	4	1	4	0	13	AC
Plagiomnium undulatum	20	5	1	12	6	38	C
Plagiothecium cavifolium	3					<5	R
Plagiothecium curvifolium	5					3	R
Plagiothecium denticulatum	8	1		1		7	AR
Plagiothecium nemorale	19	1	1	5		18	AC
Plagiothecium undulatum	4					<5	R

	observed frequencies					estimated relative frequency	class of rarity
	Z1	Z2	Z3	Z4	Z5		
Platygyrium repens	1					<1	RR
Pleuridium acuminatum	1					<1	RR
Pleuridium subulatum	6	3	2	3		11	AC
Pleurozium schreberi	2	2				<5	R
Pogonatum aloides	3					<5	R
Pogonatum nanum	1	1				<5	R
Pohlia annotina	3	1				<5	R
Pohlia lutescens		1				<1	RR
Pohlia melanodon	9	1	2	4		13	AC
Pohlia nutans	22	2	5	4	2	31	C
Pohlia wahlenbergii	4					<5	R
Polytrichum formosum	23	2	1	4		22	AC
Polytrichum juniperinum	2	3	3	2	1	11	AC
Polytrichum piliferum		1				<1	RR
Pottia bryoides		1				<1	RR
Pottia davalliana				1	1	<5	R
Pottia intermedia	2			1		<5	R
Pottia truncata	3	3	8	6	2	25	AC
Pseudephemerum nitidum			1			<1	RR
Pseudocrossidium hornschuchianum		1				<1	RR
Pseudocrossidium revolutum	1				1	<5	R
Pseudotaxiphyllum elegans	22	4	1	7	4	32	C
Pylaisia polyantha	1					<1	RR
Rhizomnium punctatum	11			2		9	AR
Rhynchostegiella curviseta	4					<5	R
Rhynchostegiella tenella	1					<1	RR
Rhynchostegium confertum	15	5	7	17	8	51	CC
Rhynchostegium murale	14	2	3	9	6	33	C
Rhynchostegium riparioides	9	4	1	8	2	20	AC
Rhytidiadelphus squarrosus	17	8	7	14	6	50	CC
Schistidium apocarpum	16	6	7	13	8	50	CC
Scleropodium purum	4	4	2	1		9	AR
Sphagnum flexuosum	1					<1	RR
Tetraphis pellucida	9					6	AR
Thamnobryum alopecurum	4			3	1	7	AR
Thuidium tamariscinum	2					<5	R
Tortella tortuosa	2	1				<5	R
Tortula intermedia	1					<1	RR
Tortula laevipila					2	<5	R
Tortula muralis	37	9	16	24	18	100	CC
Tortula pagorum				1		<1	RR
Tortula papillosa		1				<1	RR
Tortula ruralis	3	2	3	3	1	12	AC
Tortula subulata	1		1	1		<5	R
Tortula virescens	2	2		2	1	6	AR

	observed frequencies					estimated relative frequency	class of rarity
	Z1	Z2	Z3	Z4	Z5		
Trichostomum crispulum				1		<1	RR
Ulota bruchii	3				1	<5	R
Ulota crispa	2	1				<5	R
Weissia brachycarpa	1	1				<5	R
Weissia controversa	1		1	1		<5	R
Zygodon viridissimus	5		1	4	1	10	AR

one square in the northern part of the Region possesses a noteworthy bryophytic richness with more than 80 species km^{-2}. This square includes in fact one of the last non-canalized rivers in Brussels: the valley of the Molenbeek, with its marshes, old willow woods and ponds. This complex of habitats possesses rich assemblages of epiphytes (*Orthotrichum pallens, O. pulchellum, O. pumilum, Tortula papillosa, T. virescens*) (maps 156, 157, 158, 216 and 219), aquatic species (*Riccia fluitans*) (map 36) and pioneer species of pond margins including *Aphanorhegma patens* and *Physcomitrium pyriforme* (maps 49 and 164). The North of Brussels is more often characterised by very disturbed places such as industrial wastelands; locally, less nitrophilous clayey soils allow the presence of species characteristic of heavy and compacted soils with low drainage, e.g. *Bryum klinggraeffii* and *Riccia glauca* (maps 68 and 35).

4.3 Assessment of the diversity and rarity

The 225 species represent about 33% of the Belgian bryoflora. This is a rather high diversity in comparison with the bryoflora of other European cities (fig. 6). The first part of the graph shows a rather constant relation between floristic diversity and surface to about 50 km^2. This can probably be explained because small dense cities have few different habitats whereas large cities very often include large green areas. These can become a habitat of substitution for many forest bryophytes and therefore give rise to an increase of diversity (Mazimpaka et al. 1988). Within this framework the classification of floristic areas can be used to compare more precisely the richness between the different cities. In Brussels, the mean of 24 species km^{-2} in the urban area can be compared with the richness in species for cities sensu stricto: 26 species in Toledo (Ballesteros Segura & Ron 1985), 39 species in the centre of Segovia (Lara et al. 1991). This is nevertheless not true for cities as Rome, where the diversity decreases from 71 species per 1.6 km^2 in the centre to less than 20 species in the suburb because of the presence, in the centre, of

Table 3. List of bryophytes new to Belgium, the phytogeographical district of Brabant or the Brussels Capital Region

Belgium: *Ephemerum stellatum.*

Phytogeographical district of Brabant: *Fissidens pusillus, Orthotrichum pallens.*

Brussels Capital Region: *Amblystegium varium, Dichodontium pellucidum, Diplophyllum obtusifolium, Drepanocladus aduncus, Fissidens bambergeri, Fissidens exilis, Fissidens incurvus, Fissidens viridulus, Hygrohypnum luridum, Lophocolea semiteres, Orthotrichum pallens, Orthotrichum pulchellum, Philonotis fontana, Platygyrium repens, Pohlia lutescens, Pottia davalliana, Riccia subbifurca, Scapania irrigua, Sphagnum flexuosum, Tortula intermedia, Tortula pagorum, Tortula virescens, Trichostomum crispulum, Zygodon viridissimus.*

Table 4
Species not rediscovered in the Brussels Capital Region since 1980

Epiphytes: *Leucodon sciuroides, Neckera pumila.*

Alder forest and marshes: *Aulacomnium palustre, Calliergon cordifolium, Eurhynchium speciosum, Polytrichum commune, Sanionia uncinata, Sphagnum palustre, Warnstorfia fluitans*

Forest ground and slopes: *Bartramia pomiformis, Hylocomium splendens, Rhytidiadelphus loreus, Rhytidiadelphus triquetrus, Sphagnum compactum.*

Heaths: *Dicranum spurium, Lophozia excisa, Lophozia ventricosa.*

River banks: *Riccardia multifida.*

Aquatics: *Fontinalis antipyretica, Ricciocarpos natans.*

Calcicolous: *Bryum donianum, Bryum intermedium, Bryum torquescens, Campylium calcareum, Leptobarbula berica, Lophocolea minor, Pterogonium gracile, Pterygoneurum ovatum, Reboulia hemisphaerica, Targionia hypophylla.*

Pioneers: *Anthoceros punctatus, Archidium alternifolium, Calypogeia arguta, Ditrichum pallidum, Ditrichum pusillum, Entosthodon fascicularis, Phaeoceros laevis, Riccia beyrichiana, Sphaerocarpos michelii, Sphaerocarpos texanus, Tortula canescens, Tortula cuneifolia.*

ancient monuments and green areas (Carcano 1989). On the contrary, the maximum of 103 species km^{-2} in the forest part of Brussels can be compared with the 95 species recorded by Werner (1985) in a single IFBL square in the very rich vallée de la Pétrusse in Luxembourg.

Some of the species recorded in Brussels present a great interest because of their rarity in Belgium according to De Zuttere & Schumacker (1984) and Arts (1987). This is the case for *Calypogeia azurea, Rhynchostegiella curviseta, Riccia subbifurca, Tortula papillosa* and *T. virescens*. *Ephemerum stellatum* even figures in the European list of vulnerable species

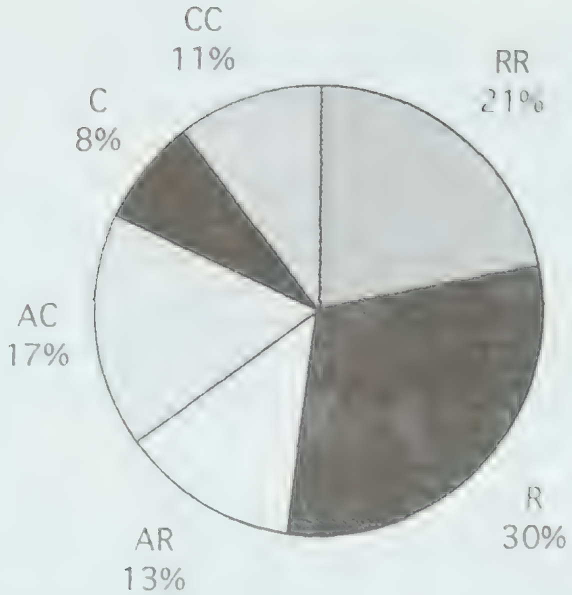


Figure 7
Distribution of the classes of frequencies

(European Committee for Conservation of Bryophytes 1995). The list of species that are rare in the phytogeographical district of Brabant is much more difficult to establish because of the lack of recent literature and of the low bryological prospection of the area. For Brussels, the rarity of the species was evaluated by calculation. The distribution of the classes of frequencies is not homogeneous (fig. 7): about 50% of the taxa of the bryoflora of Brussels have a frequency inferior to 5%, are threatened in the short term and are very likely to join the list of probably disappeared taxa. This is especially true for species producing massive but few spores whose dispersal mechanisms are not well developed and which lack asexual propagules, such as *Ephemerum* or *Physcomitrium* (Hedderson & Longton 1995) and for hepatics (Fudali 1995).

Table 5
Analysis of variance and Student t test of richness per km^2

*** $0.001 > p$
*: significantly different for $\alpha = 0.05$.
F, F th.: observed and theoretical values of the variable F

Variations	Degrees of freedom	F	F th.
between groups	4	18.97***	2.46
within groups	93		
Total	97		

Groups	n	Mean	Interval of confidence
Forest	30	49.9	6.72
Semi-natural	6	59.66	13.41
Suburban area	28	34.28*	3.32
Wasteland	15	25.46	4.87
Urban area	19	23.94	4.01

5

Discussion

5.1 The spread of the city and its influence on bryophytic habitats

The building of new areas to the detriment of the rural areas is probably the main factor of disappearance of bryophytes: destruction of heath with species such as *Dicranum spurium* or *Lophozia excisa*, calcareous slopes with species such as *Pterygoneurum ovatum*, arable fields with pioneer species such as *Anthoceros punctatus*, *Phaeoceros laevis* … In the meantime the sanitation of the town has been realised through the canalization of almost the whole hydrographic network and the filling of ponds so that all the alluvial meadows and most of the bogs with species such as *Ricciocarpos natans* have disappeared. The conservation of habitats is in this case an easy way for the conservation of the floristic richness. The conservation of habitats can be considered from two points of view.

Continuous habitats as forest paths should be managed according to some ecological considerations. In fact many communities of wet fringes of paths seem to have changed during the last decades; if the vascular plants typical of this biotope described by Delvosalle & Vanden Berghen (1959) and Vanden Berghen (1949) such as *Juncus tenuis* or *Polygonum hydropiper* still remain abundant in these situations, pioneer bryophytes as *Blasia pusilla* (map 2) seem on the contrary to have decreased and have become very rare in the forest of Soignes. These pioneer species need humid ruts where humus has accumulated and been compacted by people. The loss of the annual species is very quick (about 2 years) in undisturbed places (Vanden Berghen 1949). But the main factor of disappearance is definitely the covering of many paths with sand or calcareous gravel that has a very negative impact on these communities, because soil structure, texture, chemical reaction and humidity have been modified. This is unfortunately the case for the only known Belgian locality of *Ephemerum stellatum* (map 111) that is threatened in the short term if these practices continue.

Some places with a high floristic interest can be protected by the status of nature reserve to preserve them from disturbance. For example, local erosive processes in very popular areas are prejudicial to many species such as *Campylium calcareum* that was not rediscovered recently. Within this framework, the calcareous slopes at the "Rouge-Cloître" and the Trois Fontaines, rich in species of ancient little disturbed woodlands including *Mnium stellare* and *Plagiochila porelloides* (Rose 1992), were fortunately recently protected by the status of nature reserve. This is true as well for ashalder forests, where the conservation of old phorophytes with eutrophic bark is necessary to the conservation of their rich assemblages of epiphytes, and for some ponds and marshes as those of Jette-Ganshoren. The latter are a private nature reserve where the periodical mowing of the sedges allows the presence of the pioneer photophilous species and where old willows very rich in epiphytes are conserved. But managed nature reserves do not include other fragile biotopes such as heath and acidic grasslands that are now built up or otherwise disturbed (Vanderpoorten 1994). Interesting species such as *Dicranum spurium* disappear with them. That is why sites as the Kauwberg in Uccle, the only known locality in Brussels for taxa such as *Diplophyllum obtusifolium* or *Scapania curta* (maps 11 and 40), urgently need protection with the public restricted to designated pathways following for example the mapping of land suitability based on a phytosociological survey proposed by Tanghe (1987). The trouble is that many sites as the Kauwberg do not have the status of green area and cannot be designated as a nature reserve (Schoonbroodt 1993). Although the Kauwberg was classified, its management against for instance shrub invasion cannot be imposed and the disappearance of the silicolous grasslands with *Pogonatum nanum* and *Lophozia bicrenata* is to be expected in the short term. Some works for the improvement of the management of the environment have already been realised in Brussels. This is especially the case at the Wilder Bos in Berchem Ste. Agathe, where a board-walk regulates the circulation of the public and protects the numerous spring geophytes. These works must not be confused with much more regrettable “improvements” as those at the regional park of the Héronière in Watermael-Boitsfort, where artificial stretches of water were created by using heavy engines and alien species were planted.

Lastly, general works for the improvement of the management of the environment as well as natural reserves are not efficient against the large scale ecological problems as the drying up of the ecosystems. As an improvement of the ecological situation will not happen in the short term, the conservation of some species will have to be linked to a specifically targeted management. From this point of view, the case of the single locality of *Sphagnum flexuosum* in Brussels (map 207) has to be emphasized because it represents one of the last characteristic taxa of the rare Brabantine oligotrophic alder forest (Noirfalise & Sougnez 1961). This species, that is usually found in moist, meso-oligotrophic organic and acidic sites (Eddy & Daniels 1990), grows there in a eutrophic wet meadow with *Brachythecium rivulare* and *B. rutabulum*, that is fed by a water table close to the surface during the winter with a pH higher than 7 (Inst. Brux. Gest. Env. 1994b). The duality between the ecology of the species and its current habitat, and more particularly its trophic level, is surprising. That is why the conservation of the species is linked to a local and specialised management. This involves the mowing of the large sedges and the superficial sod-cutting nevertheless conserving a bed of peaty organic matter, useful in creating acidic conditions against the alkalinity of the water table. This management has shown positive effects on the development of the *Sphagnum* in one year but care must be taken to prevent the invasion of the bare peat by *Polygonum hydropiper*.

5.2 Influence of air quality on the bryoflora

Pollution by SO_2 was visible in Brussels some decades ago. Between 1969 and 1970, maxima superior to 750 $\mu g.m^{-3}$ and means between 100 $\mu g.m^{-3}$ in the suburb to 300 $\mu g.m^{-3}$ in the centre were recorded (Derouane et al. 1972). Lichens have frequently been used as indicator species for air quality (e.g. Barkman 1958, Farmer et al. 1992). As for the lichenic flora, air quality is often considered as a decisive element on the composition of bryophyte populations (Leblanc et al. 1966, Gilbert 1968, 1970a, b, Rao 1982, Bates et al. 1990, Sjögren 1995). This influence, already perceptible in large cities as Paris at the middle of the century (Bouly de Lesdain 1948), generates several types of behaviour. The processes of acidification could explain the disappearance of the most sensitive taxa such as *Leucodon sciuroides* and the loss of *Rhytidiadelphus triquetrus* and *Hylocomium splendens* in acidic conditions (Farmer et al. 1992). In the meantime, some acidophilous species may have expanded their range due to bark acidification (Farmer et al. 1992). This could be the case in Brussels for several Dicranaceae not recorded in Brussels during the last century (Delogne & Durand 1887) such as *Dicranum montanum* (map 96), that appears very rarely in the records of Heinemann & Vanden Berghen (1944), or for *D. tauricum* (map 98), said to be very rare in Brabant at the middle of the 20th century (Demaret & Castagne 1959), which is now rather common on old beech and very often bears capsules.

For some years now, the pollution by sulphur dioxide has been decreasing in Brussels. Since 1991 annual concentrations of SO_2 have been around 25 $\mu g.m^{-3}$ with maxima of about 215 $\mu g.m^{-3}$ (Inst. Brux. Gest. Env. 1994b). The decrease of pollution by sulphur dioxide is general and is presented as the cause of the recovering of sensitive cryptogams (Gilbert 1992, Porley 1996). This could as well concern some species of bryophytes in Brussels. Orthotrichaceae are especially concerned, as two new species were found and as some species, e.g. *O. affine* (map 150), are really very abundant now. These species are typically found on short-lived trees such as elders and willows that were probably not affected by the high pollution of sulphur dioxide during the years 1960-1970.

To map the influence of sulphur dioxide on the epiphytic bryoflora, the biological scale of annual concentration means of SO_2 (Gilbert 1970a) was used. In Brussels, characteristic epiphytes according to this scale are:

- no epiphytes for $[SO_2] > 40\ \mu g/m^3$;
- *Hypnum cupressiforme* and *Dicranoweisia cirrata* for $[SO_2] < 40\ \mu g/m^3$;
- *Metzgeria furcata, Orthotrichum affine, Tortula laevipila* for $[SO_2]$ close to $0\ \mu g/m^3$.

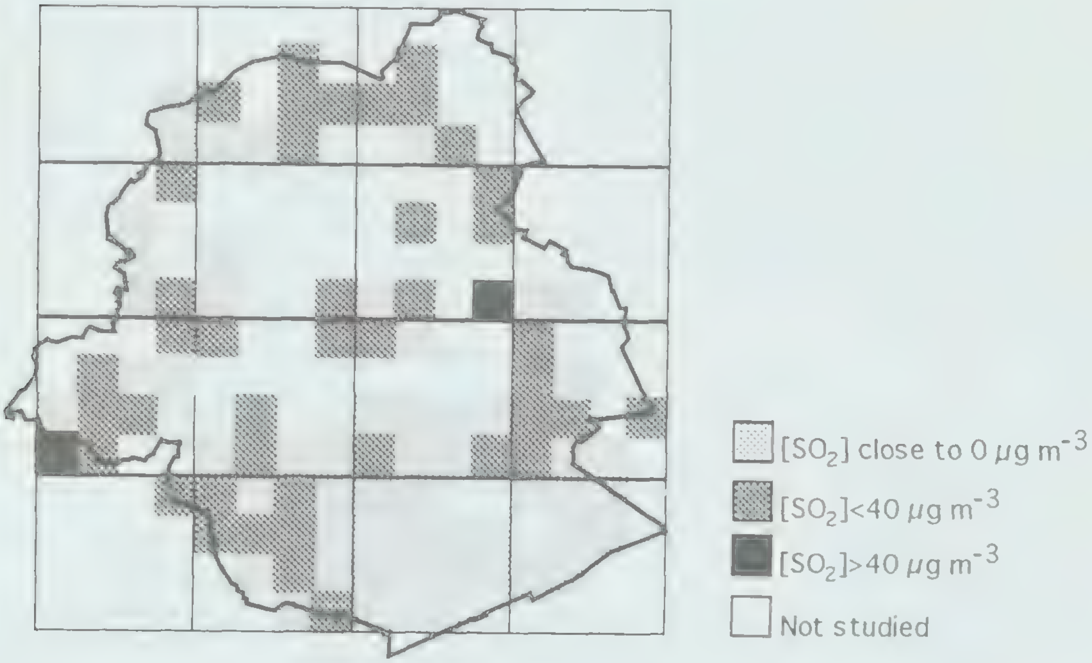

▨ $[SO_2]$ close to 0 $\mu g\ m^{-3}$
▨ $[SO_2]<40\ \mu g\ m^{-3}$
■ $[SO_2]>40\ \mu g\ m^{-3}$
☐ Not studied

Figure 8. Patterns of sulphur dioxide concentration according to the epiphytic bryophytes.

Nevertheless, many other parameters have to be considered to explain the decrease of some species belonging to the epiphytic vegetation. This could partly explain why the pattern of sulphur dioxide concentrations according to the epiphytic bryophytes is not convincing (fig. 8). In fact, the sensibility of the several taxa varies according to the chemical reaction of the bark they grow on; acidity due to sulphur dioxide is not neutralized on barks low in alkali, so that the outcome of the reaction favours the increase of toxic molecules of SO_4^{3-} (Gilbert 1968, 1970b). Also, the decrease of evapotranspiration in the urban environment causes a decrease in air humidity of about 6%, despite rainfall in cities is higher by about 10% with regard to neighbouring countryside due to the presence of a dust cloud which favours condensation (Duvigneaud 1974). This is very unfavourable to the epiphytes (Barkman 1958).

The combination of these processes could partly explain why *Hypnum cupressiforme* is a common epiphytic species in the forest of Soignes but grows in the centre of the city only at the base of trees. But the bioindication must be based on the combination of common species and cannot explain the distribution of rare species such as *Tortula laevipila* (map 213), which is supposed to be pollution-sensitive and which is found in Brussels only in the centre of the city.

Other pollutants can at least partly explain the distribution of the bryoflora. This is for example the case for *Orthotrichum diaphanum* (map 153), which is rather rare in the forest of Soignes due to the oligotrophic bark of the beeches, but which is very abundant everywhere else, both epilithic as well as epiphytic, where it could be favoured by waste gases rich in NO_x. In the meantime, the slight increase of particles in suspension since 1970 due to road traffic and central heating (Inst. Brux. Gest. Env. 1994b), allows epilithic species, e.g. *Grimmia pulvinata, Bryum argenteum, Tortula muralis*, to take the place of genuine epiphytes on the dust enriched barks in the most polluted areas, according to a process already demonstrated for lichens (Hawksworth & Mc Manus 1988).

Table 6. Assemblages of aquatic bryophytes for the monitoring of water quality

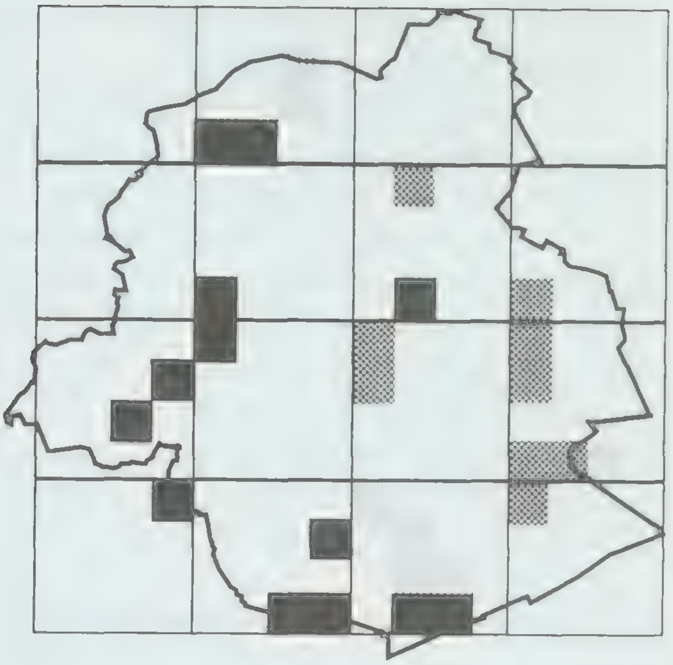
	Stagnant	Running
Hypertrophic and saprobic	*Amblystegium riparium*	*Rhynchostegium riparioides*
Eutrophic saprobic to mesosaprobic	*Cratoneuron filicinum* *Pellia endiviifolia* (*Hygrohypnum luridum*) (*Riccia fluitans*)	*Fissidens crassipes* *Cratoneuron filicinum* (*Marchantia polymorpha* var. *polymorpha*) (*Didymodon tophaceus*) (*Cinclidotus fontinaloides*)
Mesotrophic oligosaprobic	(*Didymodon spadiceus*)	*Cratoneuron filicinum* *Fissidens gracilifolius* *Chiloscyphus polyanthos* (*Dichodontium pellucidum*) (*Hygrohypnum luridum*) (*Amblystegium tenax*) (*Fissidens pusillus*) (*Rhynchostegiella curviseta*)

5.3 Influence of hydrology on the bryoflora

5.3.1 Aquatic bryoflora with regard to trophic and saprobic levels: a qualitative correlation

The mineralisation of water explains the abundance of calcicolous taxa such as *Cratoneuron filicinum* (map 84) and the rarity of taxa characteristic of less hard waters such as *Hygrohypnum luridum* (map 136) (Empain et al. 1980). That is why the eutrophication of the mineralised waters obliges this species to grow above the surface level to satisfy its hydrophily. Plants are thus not

Figure 9
Assessment of the quality of running water.



in an ecological optimum and present atypical leaves with a very short costa or with none at all.

Temperature, trophic and saprobic components occur secondly to determine the combination of taxa able to colonize a stretch of water. Temperature has obviously played a role in the case of mosses such as *Fissidens crassipes* (map 121), a species formerly unknown in Brussels. This species sensitive to frost is spreading in the Netherlands due to the warm water effluents (Florschütz et al. 1972, Touw & Rubers 1989) and is probably favoured in Brussels by the mild temperatures of the urban mesoclimate. Trophy and saproby were assessed by a qualitative system based on the aquatic bryoflora (table 6, fig. 9, 10). For each km^2, the best bioindication value is represented. Stagnant waters are more sensitive to pollution than running waters so that only a mesotrophic oligosaprobic pond fed by a spring is present in the study area. Occasional species that cannot faithfully be used for bioindication in Brussels are in parentheses. The particular case of *Dichodontium pellucidum* can be emphasized; this moss, characteristic of rocky habitats, was found in two localities in the forest of Soignes (map 87), where the often sandy deposits of rivers are unfavourable for it so that the plant appears in a very small form with propagules. The sandy deposits are, in other respects, a limiting factor for the aquatic bryoflora which cannot be used for bioindication in this case.

Only two aquatic species formerly recorded in Brussels were not rediscovered. Whereas the disappearance of *Ricciocarpos natans* cannot be explained because its former locality is not known with enough precision, the

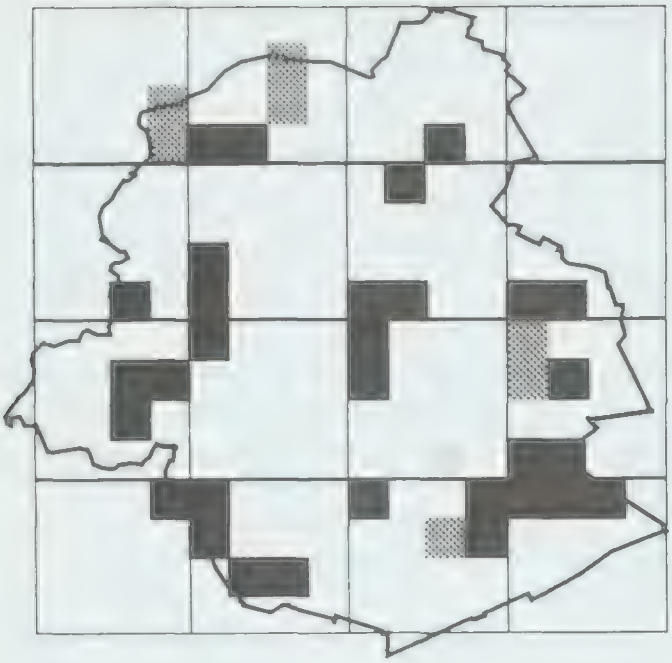


Figure 10
Assessment of the quality of stagnant water.

disappearance of *Fontinalis antipyretica* could be linked to the new arrangements for angling on the pond at the Rouge-Cloître, its only locality. Thus trophic and saprobic levels do not seem to be a very limiting factor for the bryoflora.

5.3.2 Responses of the bryoflora to the variations of the water table

The drainage of the forest in an attempt to grow beech and the pumping by the water company and authorized industries that reached 5.5 millions of m^3 in 1988 (Inst. Brux. Gest. Env. 1994a) are probably the causes of the fall of the water table in the forest of Soignes. Consequences for the bryoflora are obvious and appear through the loss of species characteristic of marshes including *Sphagnum palustre* and *Aulacomnium palustre*. Indirectly, the loss of erosive power of the streams causes the collapsing and crumbling of the river banks leading to the silting-up of rivers (Marlier 1971). Pleurocarpous species are thus able to develop to the detriment of pioneer species such as *Dicranella rufescens*. In the meantime, the fall of the water table causes the acceleration of some dynamic processes, e.g. the drying-up of the calcareous tufa, with the quick spread of *Conocephalum conicum* to the detriment of tuff-erecting species such as *Cratoneuron* and *Eucladium verticillatum* (De Zuttere 1983).

The fall of the water table causes the diminution of air humidity which is very unfavourable for the epiphytes (Barkman 1958). Thus the flora presents a quantitative lack, which becomes obvious through the reduction of the aeroxerophilous gradient of species along the phorophyte to few real epiphytic xerophilous species (mainly *Dicranoweisia cirrata*) restricted at the foot of trees (De Zuttere & Sotiaux 1992a). This causes the disappearance or the decrease of hygrophilous bryophytes such as *Leskea polycarpa*, *Frullania dilatata* or *Lejeunea ulicina*; both hepatics were qualified as rather common by Heinemann & Vanden Berghen (1944) but are currently very rare (maps 13 and 16). *Leskea polycarpa* (map 143) was recorded in several places on trees (Delogne & Durand 1883, Demaret 1937) but it was rediscovered in a single place where it has to compensate for the lack of atmospheric humidity by growing on moist soil together with *Riccia fluitans* and *Amblystegium riparium*. It is probable that the ecological gap so caused gives the possibility for species with asexual reproduction such as *Dicranum tauricum* (map 98) to spread massively.

Acknowledgements

Sincere thanks are due to Dr. H. Stieperaere for his numerous comments on the manuscript and his suggestions appertaining to the methodology and to Dr. T. Arts, A. Sotiaux and Dr. H. Stieperaere for their checking or confirmation regarding much of the material. I am also grateful to Dr. A.J.E. Smith for giving his opinion on the collection of *Bryum dunense*. Some floristic data were kindly communicated by A. Sotiaux; Dr. M. Gryseels and J.C. Prignon showed me the locality of *Sphagnum flexuosum*. I would like also to extend my thanks to Dr. M. Dufrêne who provided a map in pict format with the outlines of Brussels and, last but not least, to Mrs. J. Bock and J. Rose who were very kind to correct the English of this paper.

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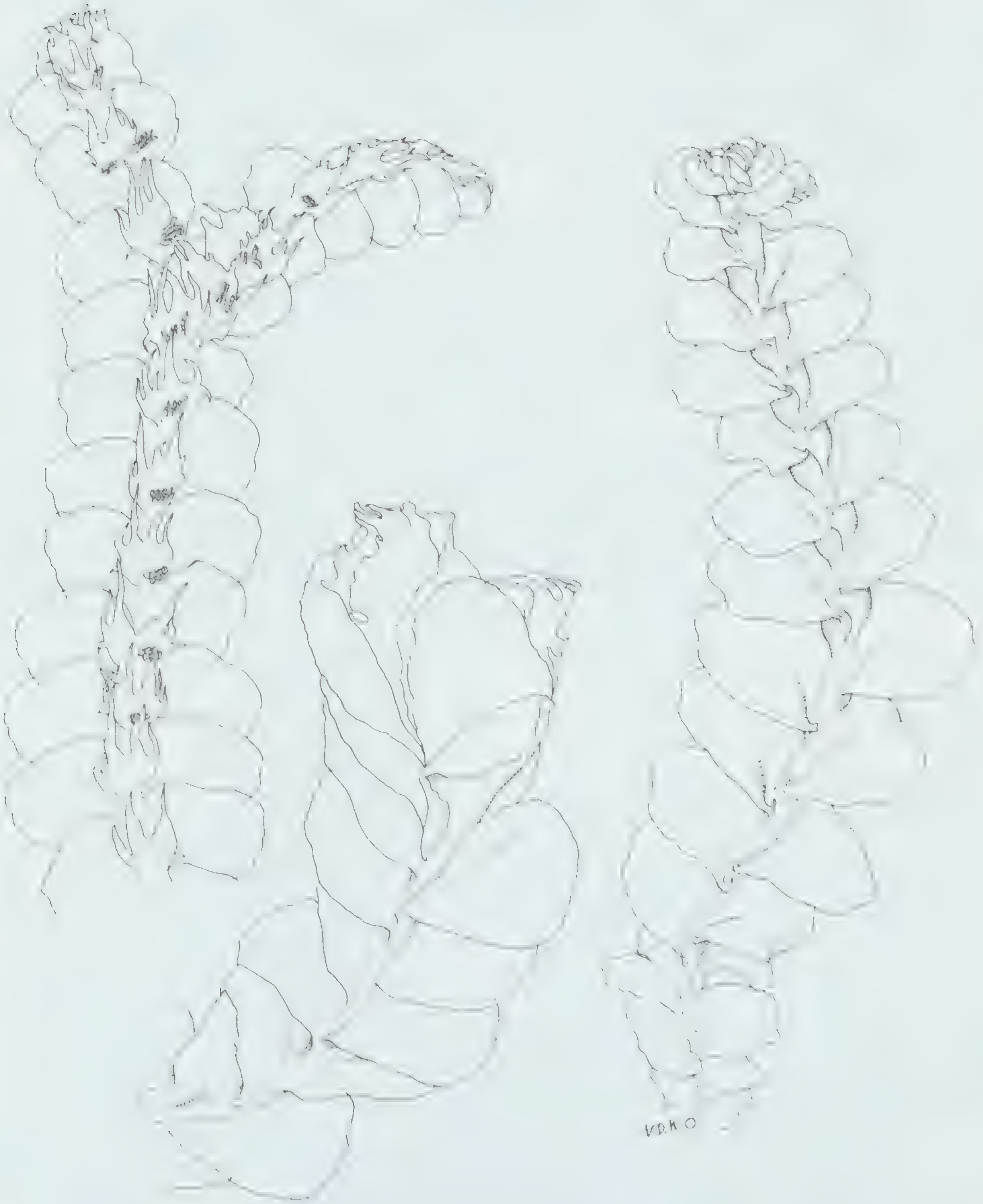
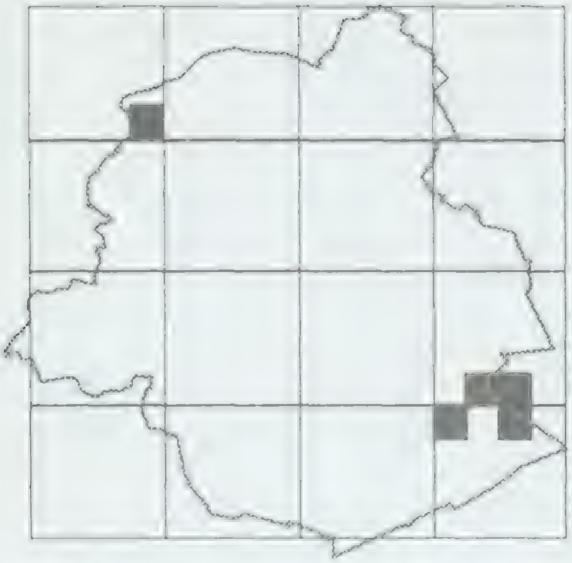


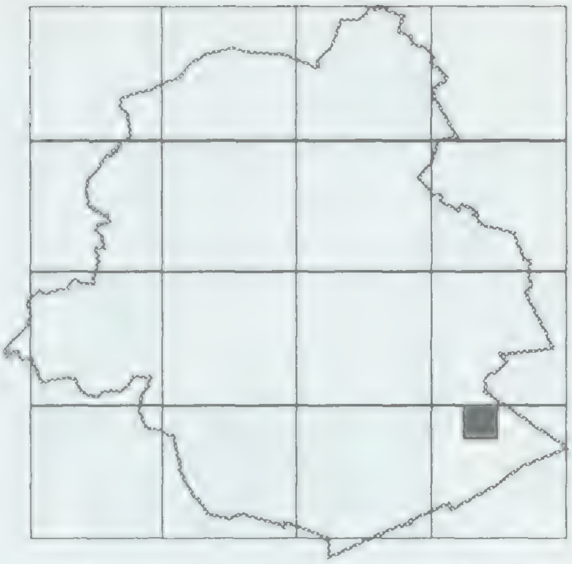
Lophocolea semiteres
From left to right:
ventral view of branch, dorsal view of branch with perianth, dorsal view of male branch.
Courtesy Vlaamse Werkgroep Bryologie en Lichenologie

Distribution maps

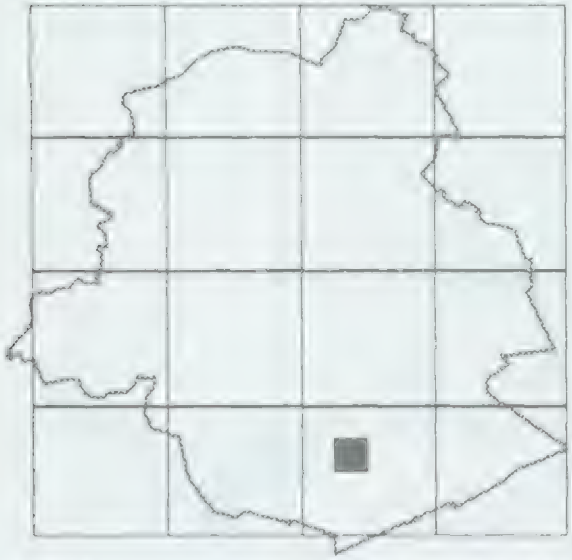
Liverworts



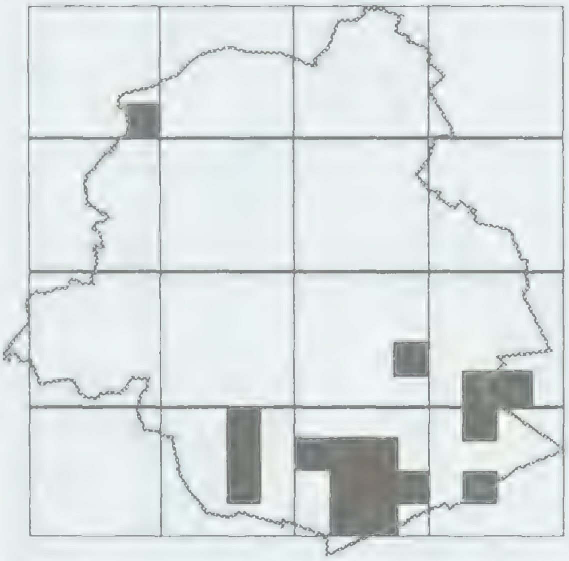
Map 1 Aneura pinguis



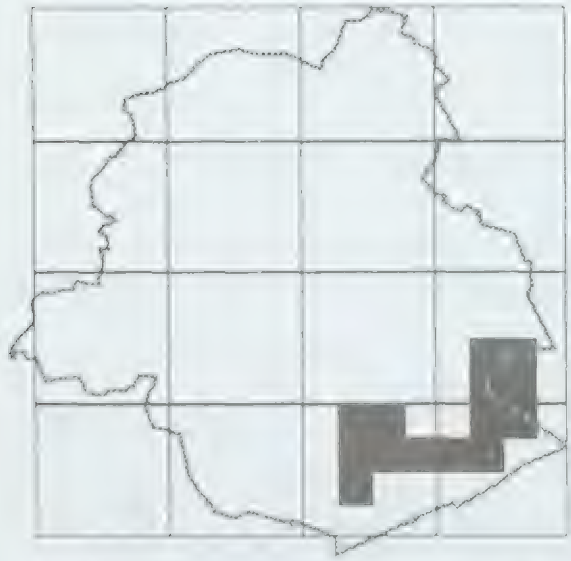
Map 2 Blasia pusilla



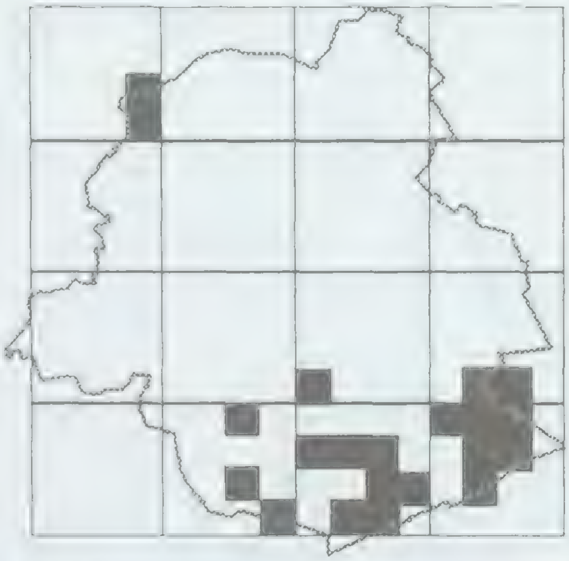
Map 3 Calypogeia azurea



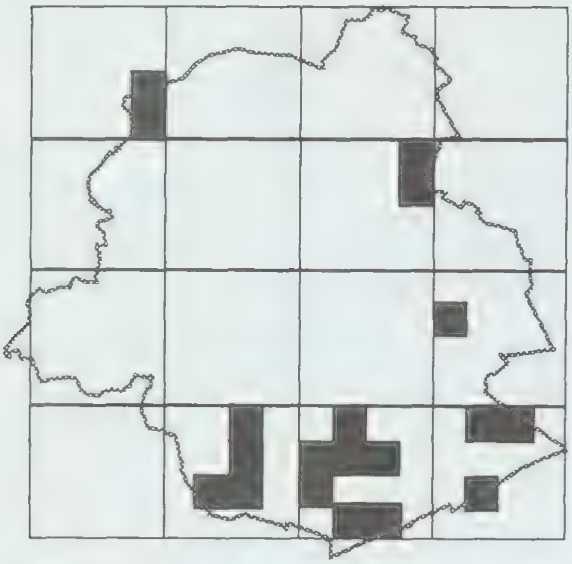
Map 4 Calypogeia fissa

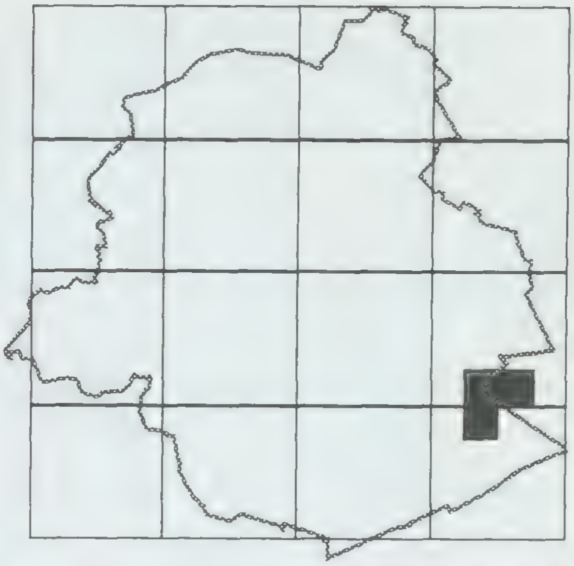


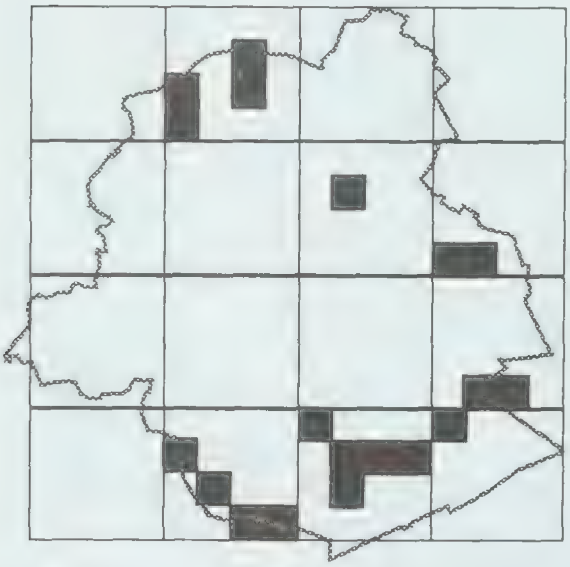
Map 5 Calypogeia muelleriana

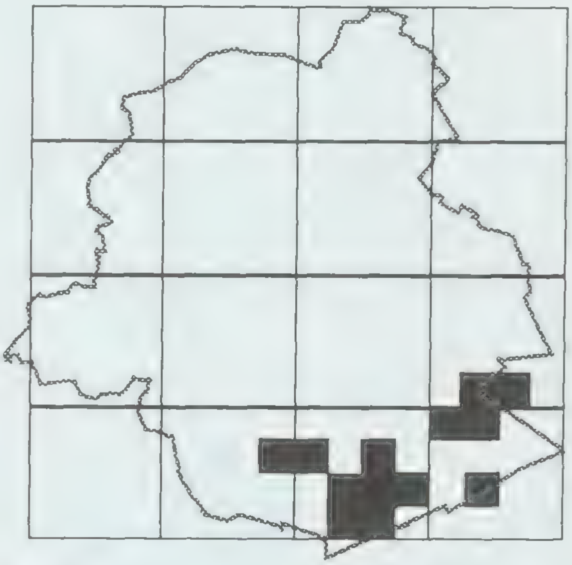


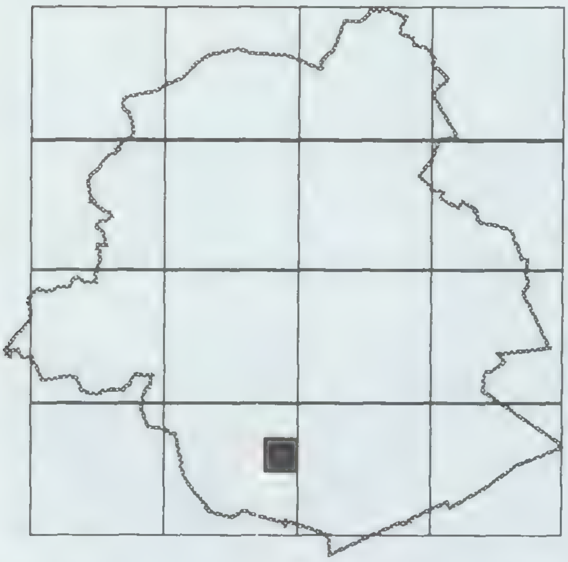
Map 6 Cephalozia bicuspidata

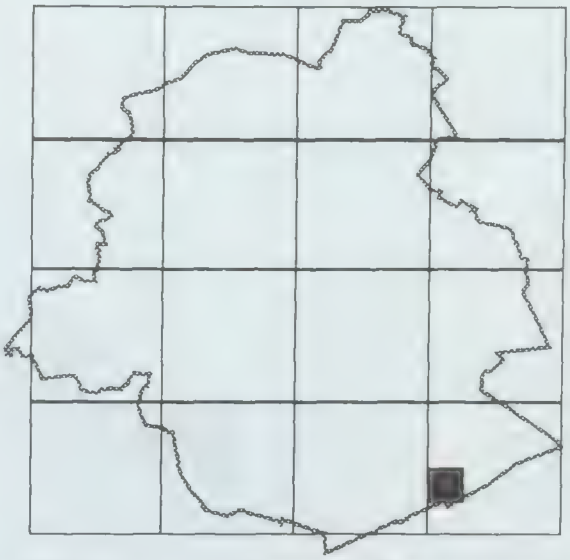

Map 7 Cephaloziella divaricata

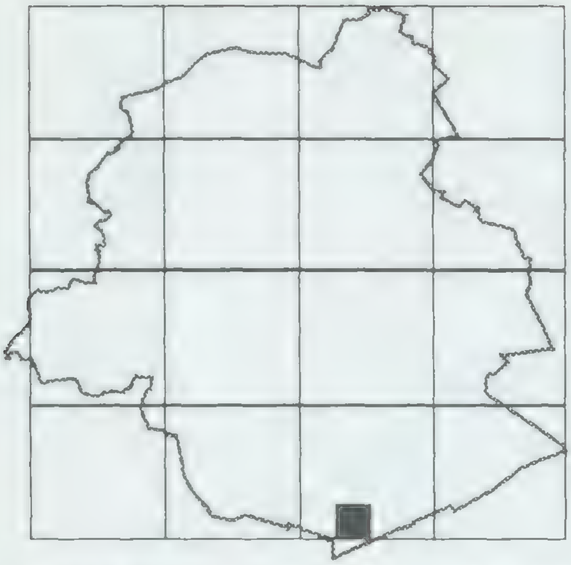

Map 8 Chiloscyphus polyanthos


Map 9 Conocephalum conicum

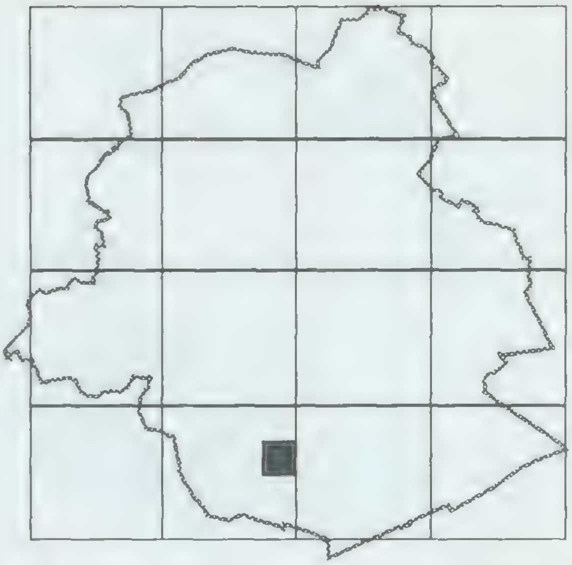

Map 10 Diplophyllum albicans


Map 11 Diplophyllum obtusifolium

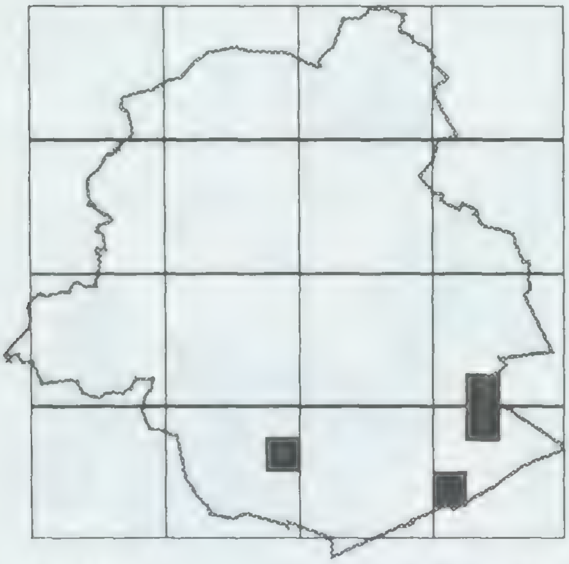

Map 12 Fossombronia wondraczeckii



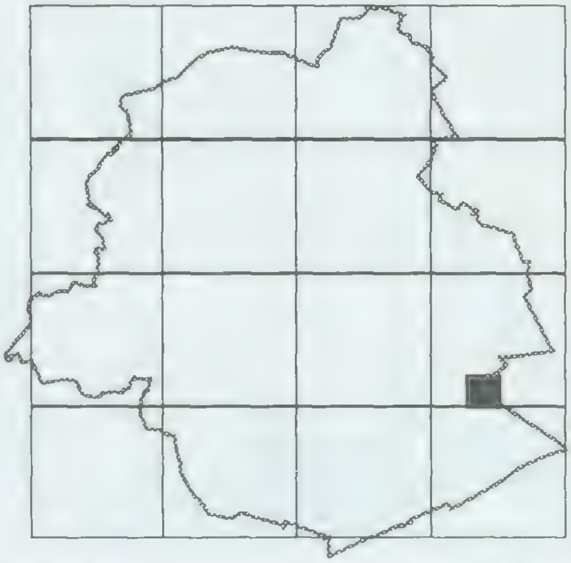
Map 13 Frullania dilatata



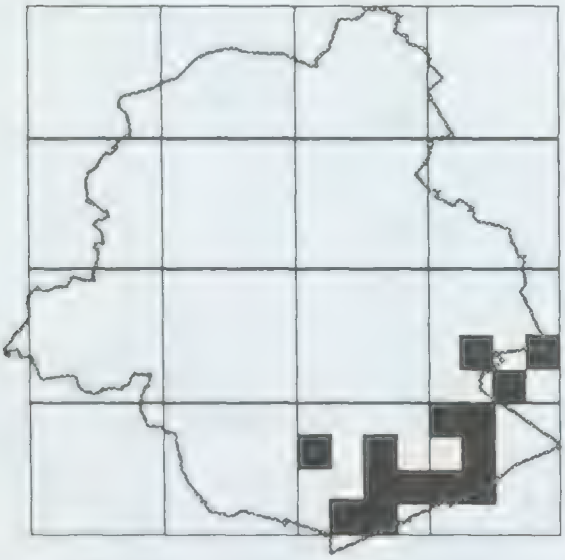
Map 14 Gymnocolea inflata



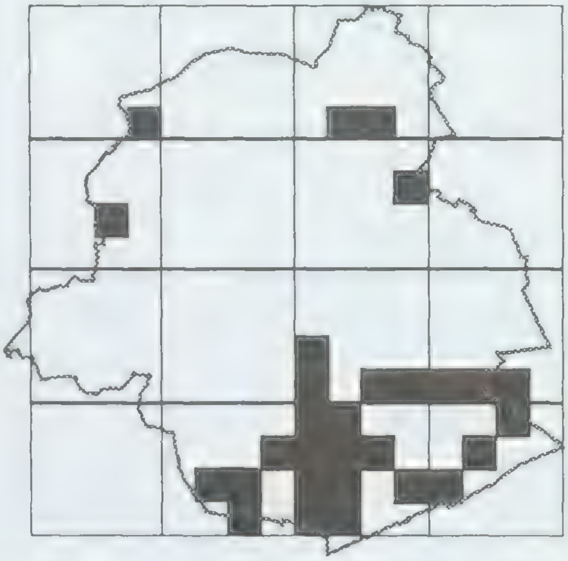
Map 15 Jungermannia gracillima



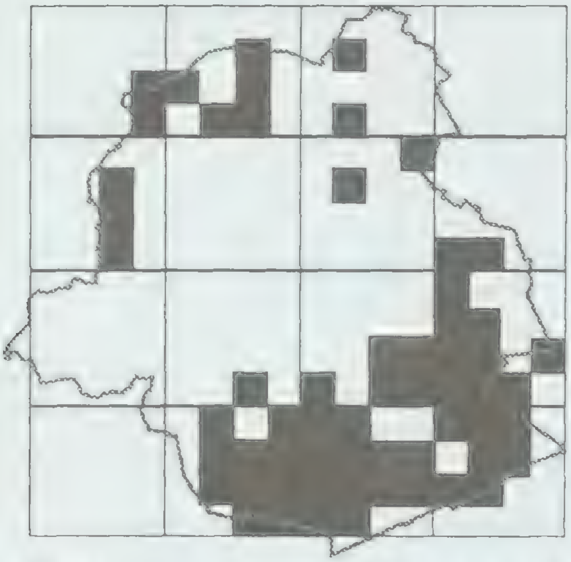
Map 16 Lejeunea ulicina



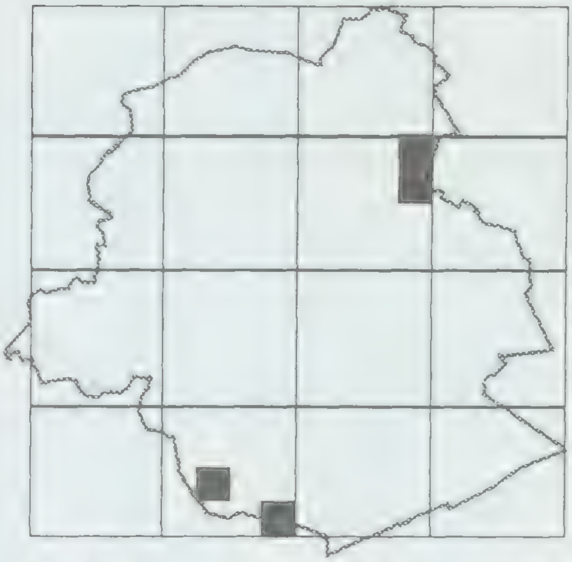
Map 17 Lepidozia reptans



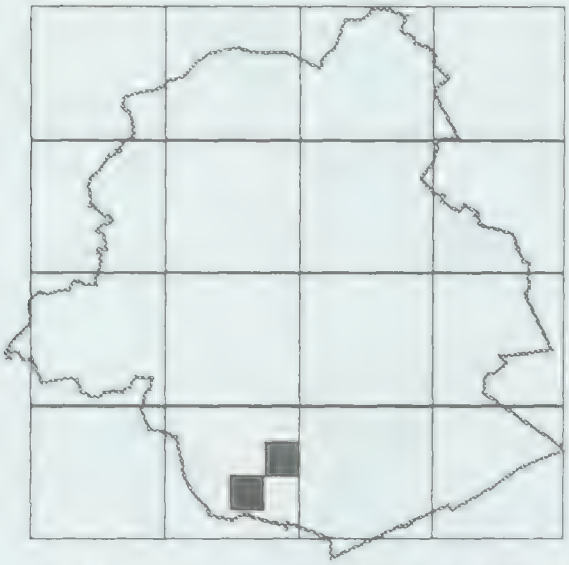
Map 18 Lophocolea bidentata



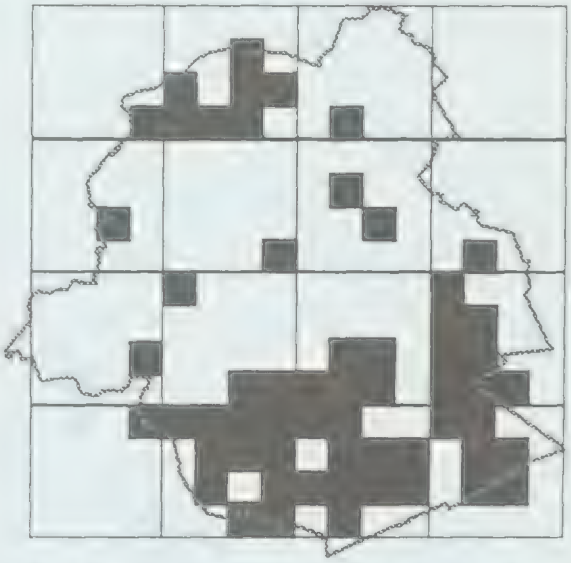
Map 19 Lophocolea heterophylla



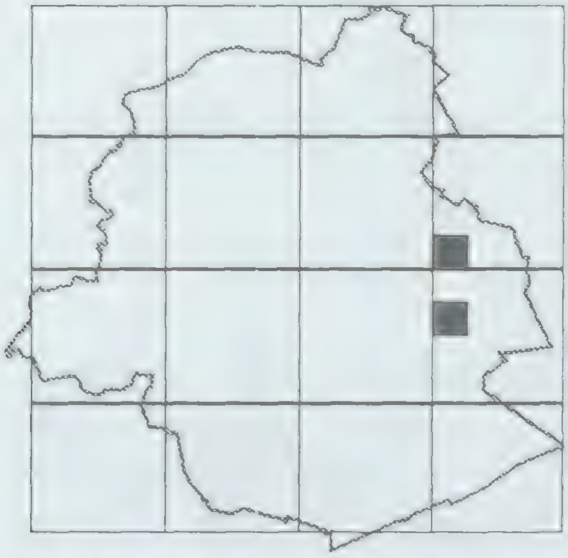
Map 20 Lophocolea semiteres



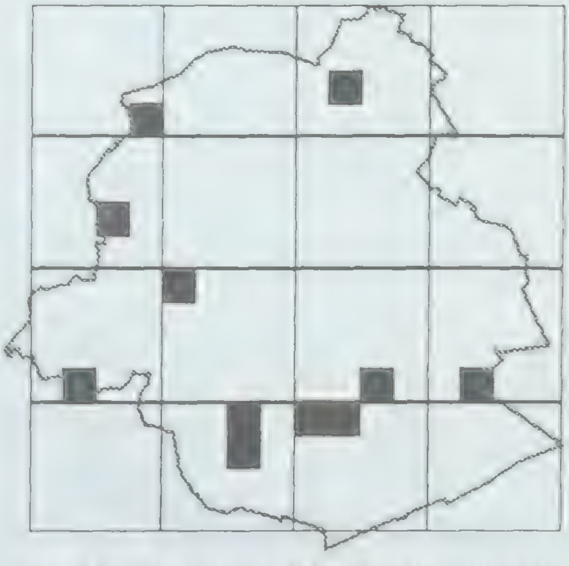
map 21 Lophozia bicrenata



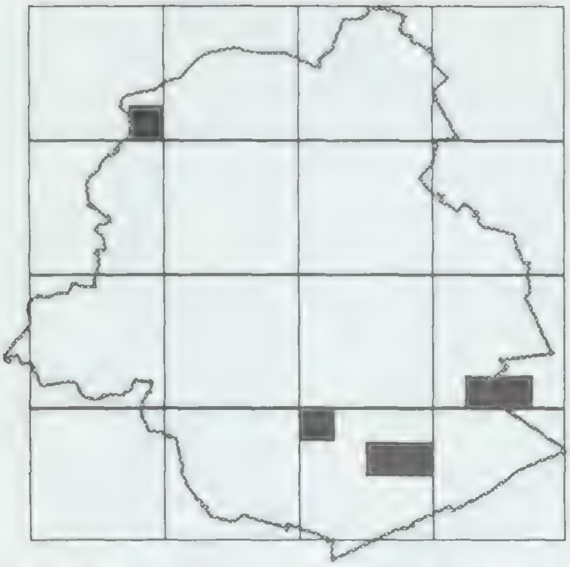
Map 22 Lunularia cruciata



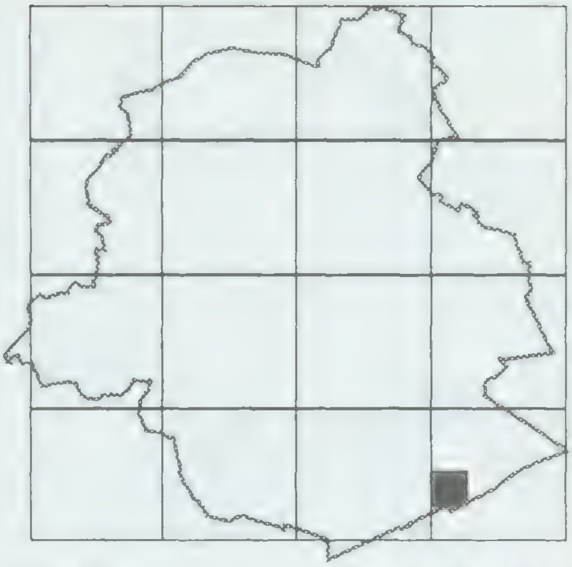
Map 23 Marchantia polymorpha var. polymorpha



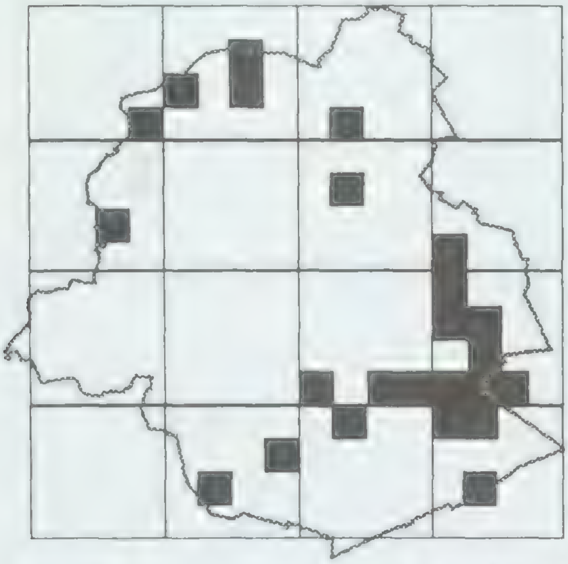
Map 24 Marchantia polymorpha var. ruderalis



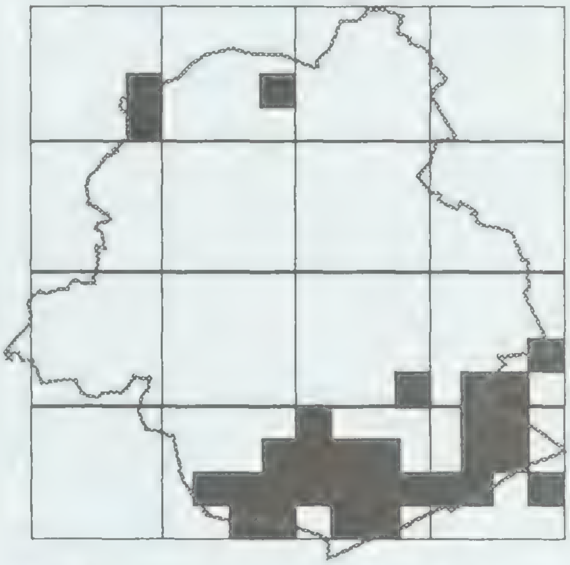
Map 25 Metzgeria furcata



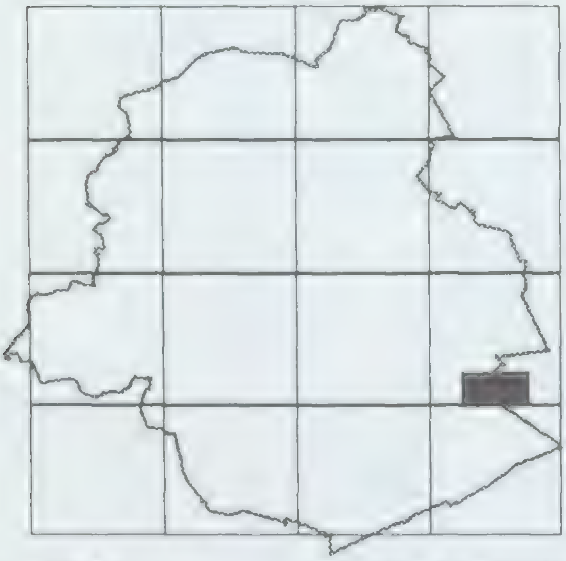
Map 26 Nardia scalaris



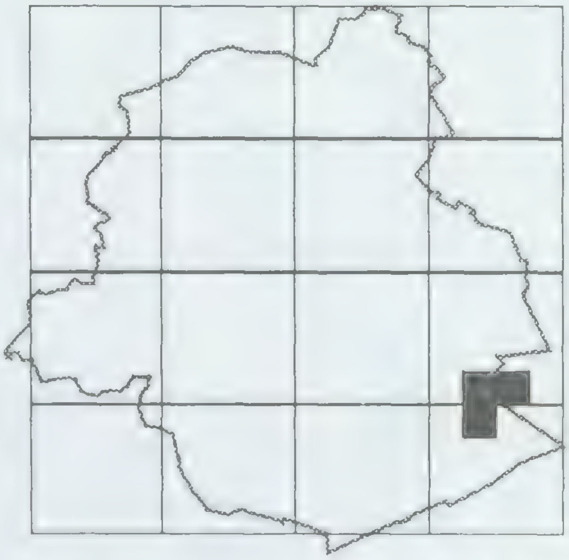
Map 27 Pellia endiviifolia



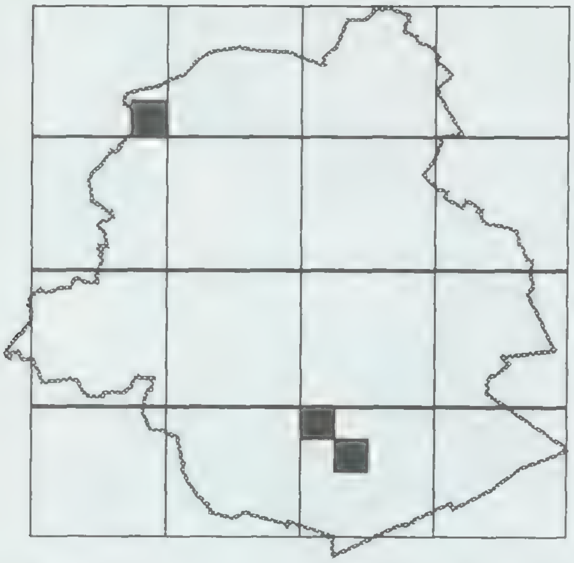
Map 28 Pellia epiphylla



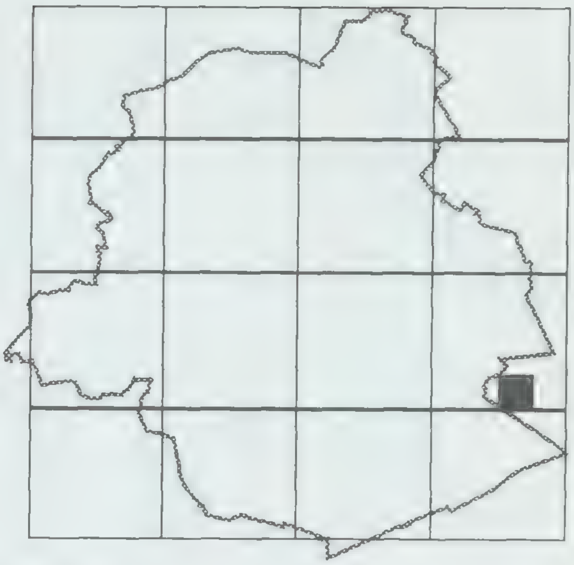
Map 29 Plagiochila asplenioides



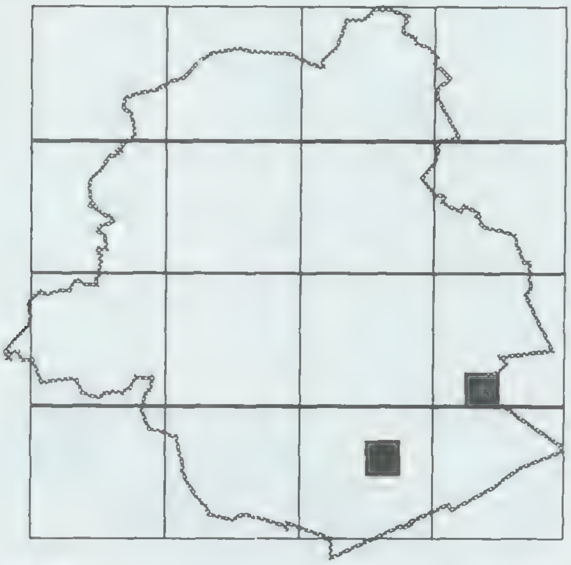
Map 30 Plagiochila porelloides



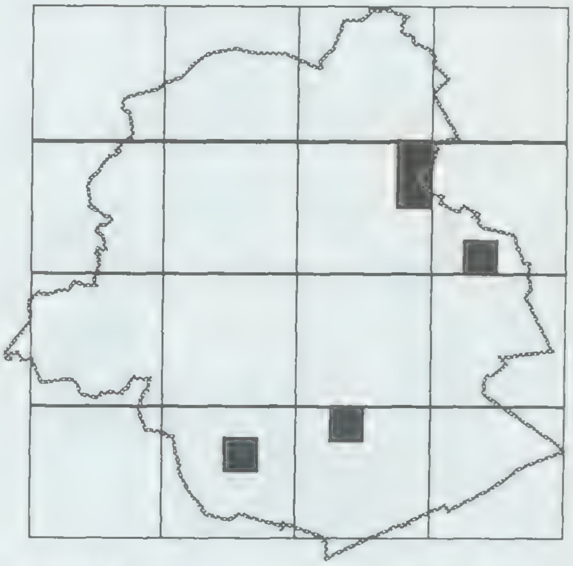
Map 31 Porella platyphylla



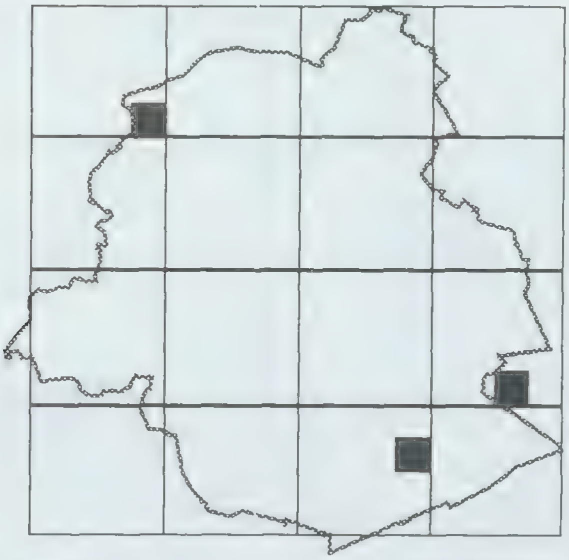
Map 32 Ptilidium pulcherrimum



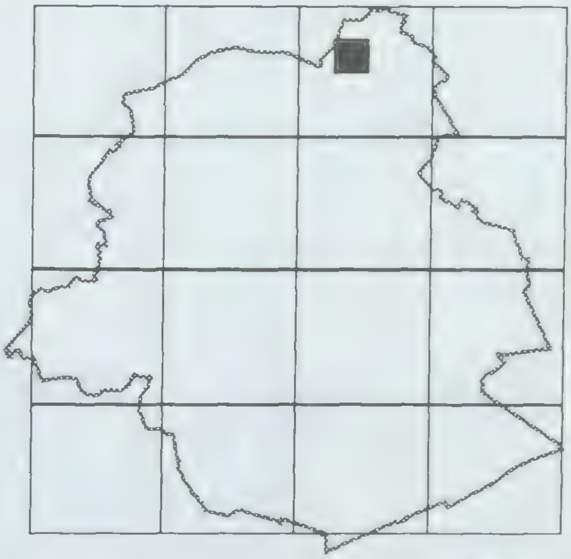
Map 33 Radula complanata



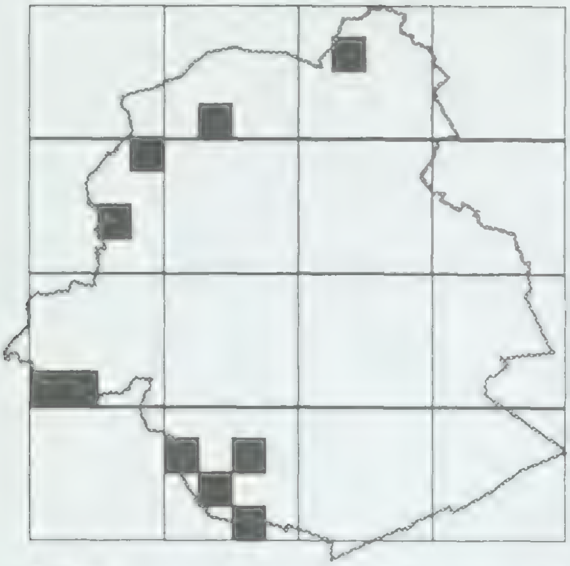
Map 34 Riccia bifurca



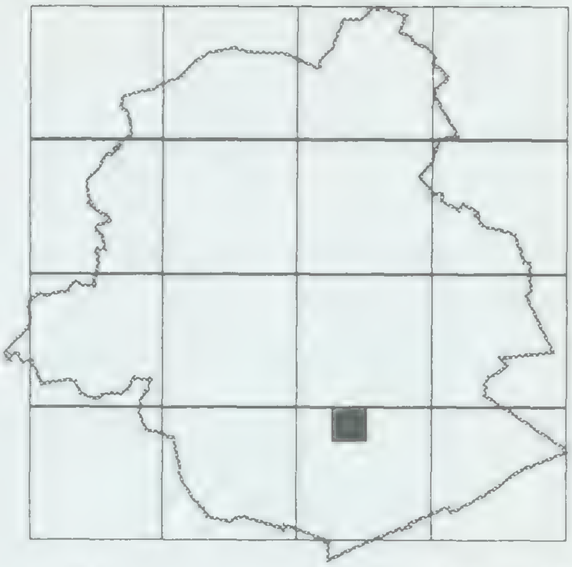
Map 35 Riccia fluitans



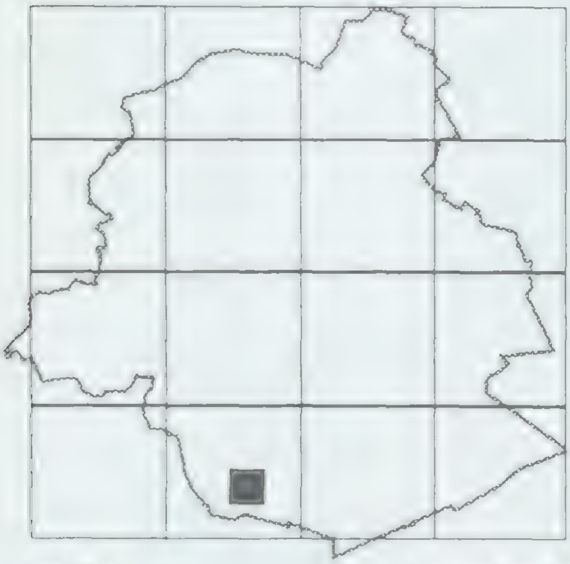
Map 36 Riccia glauca



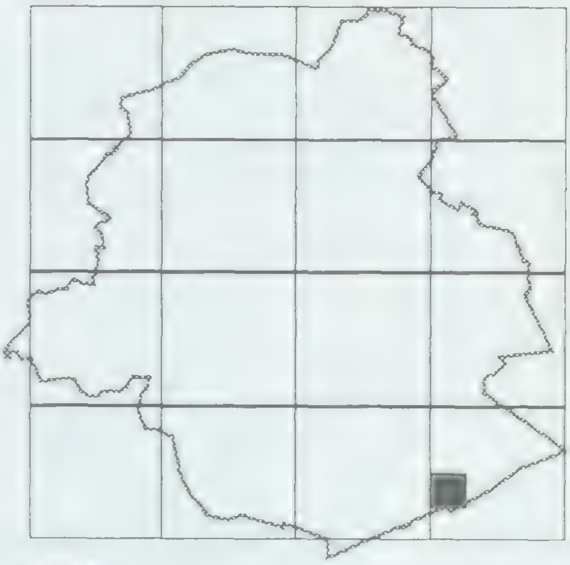
Map 37 Riccia sorocarpa



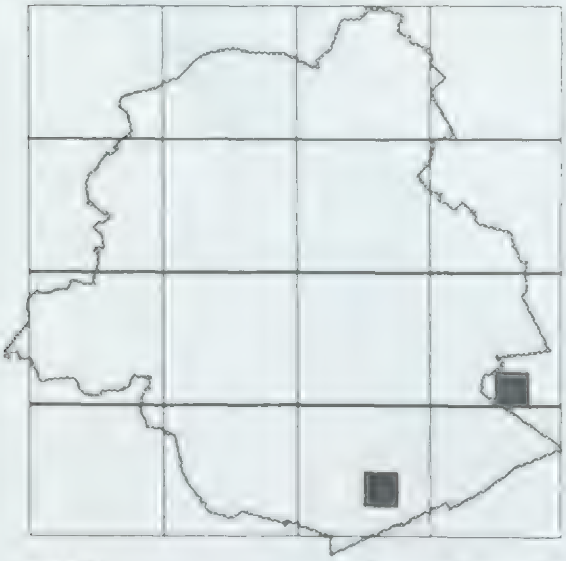
Map 38 Riccia subbifurca



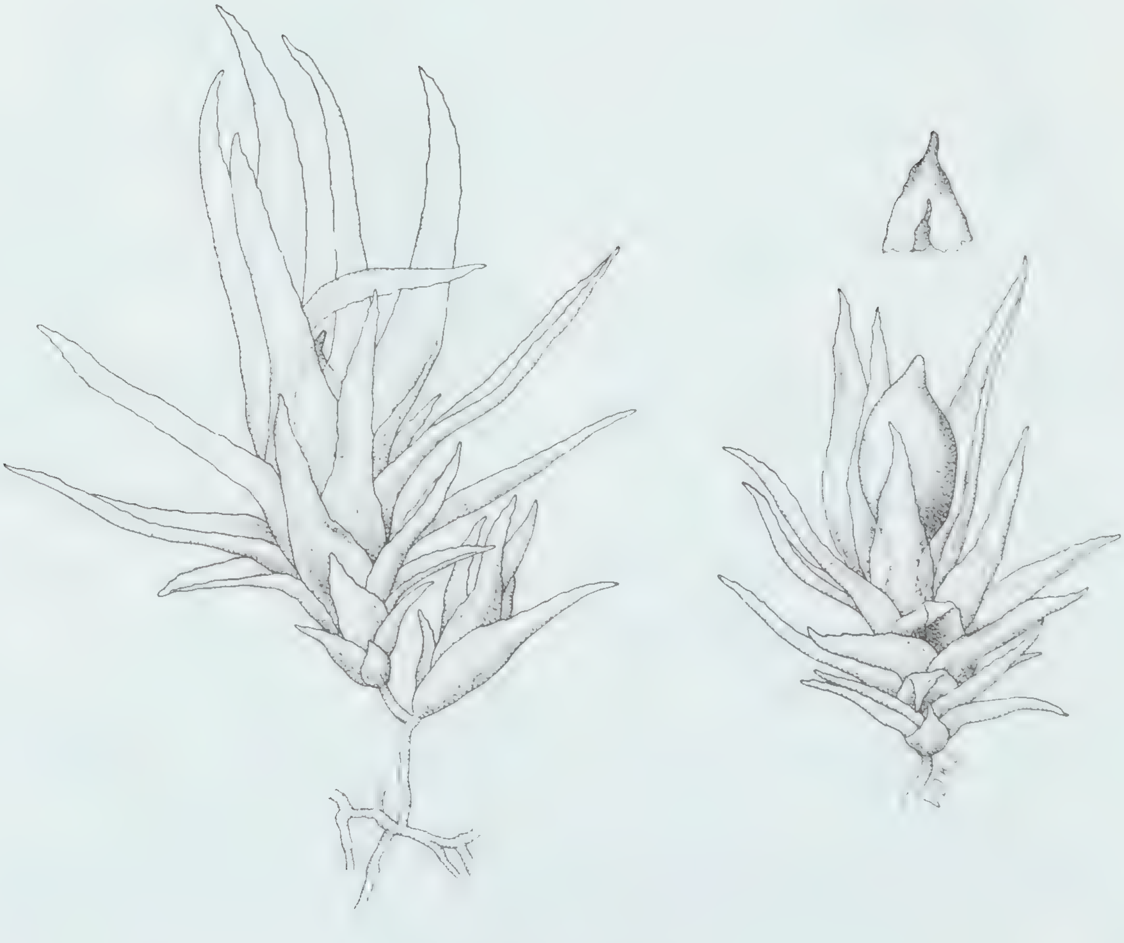
Map 39 Scapania curta



Map 40 Scapania irrigua

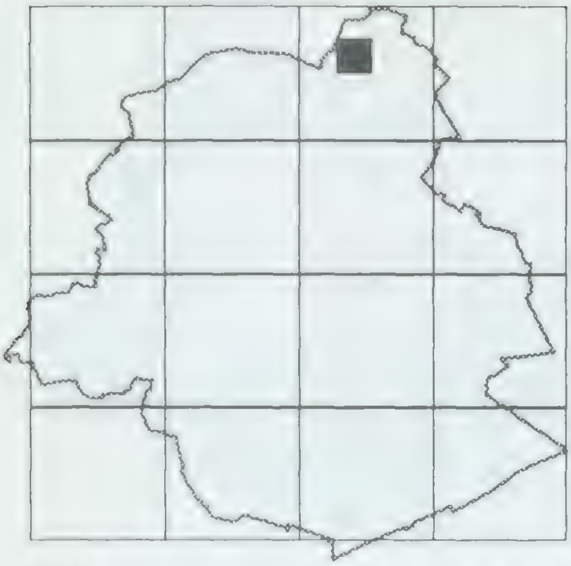


Map 41 Scapania nemorea

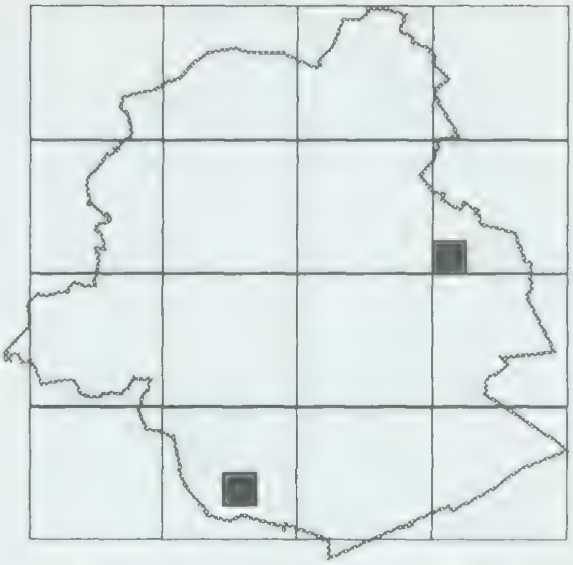


Ephemerum stellatum,
first Belgian found.
Left, female plant with male shoot at the base; right, female plant with mature sporophyte
(after Vanderpoorten et al. 1996;
courtesy Royal Botanical Society of Belgium*).*

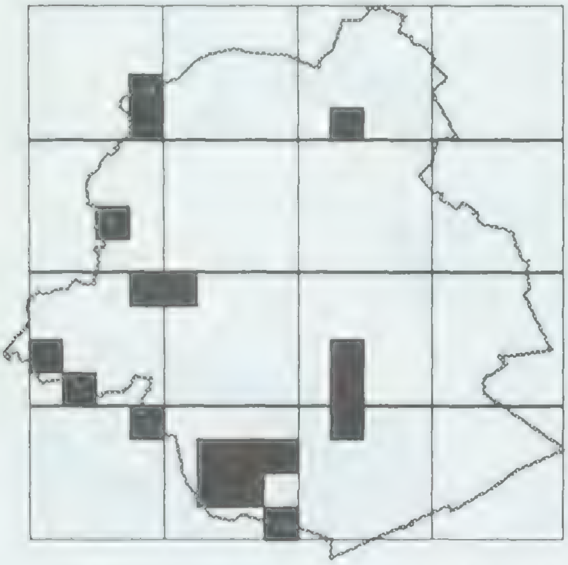
Mosses



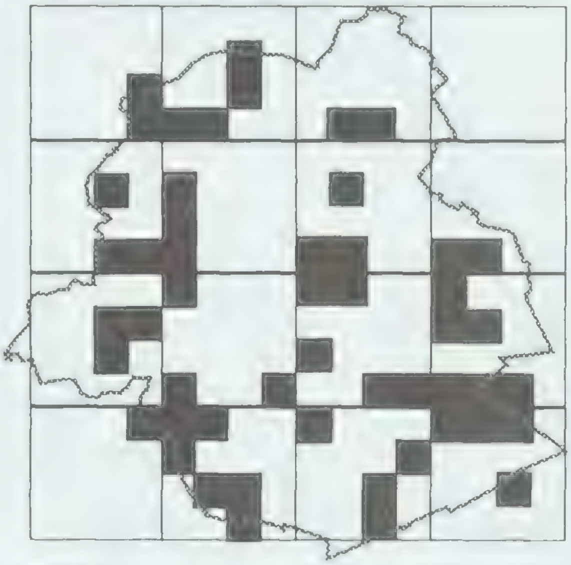
Map 42 Acaulon muticum



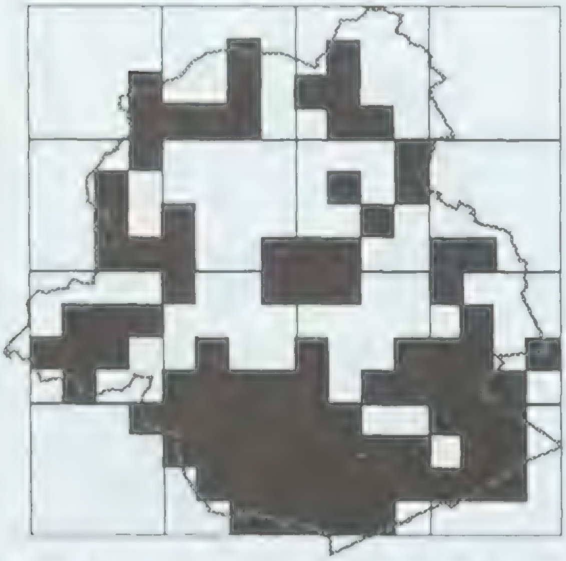
Map 43 Aloina aloides



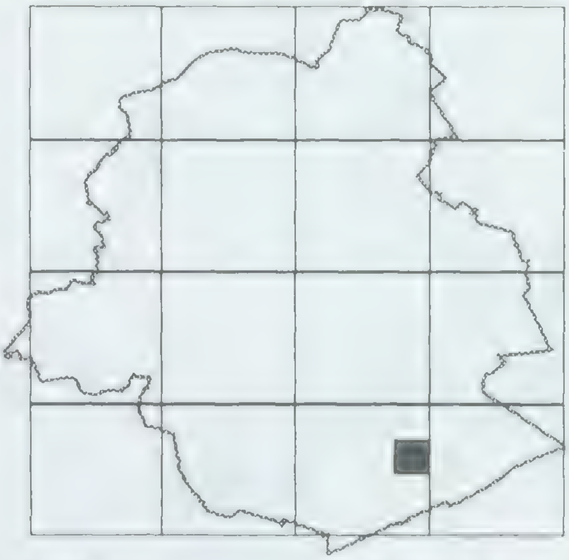
map 44 Aloina ambigua



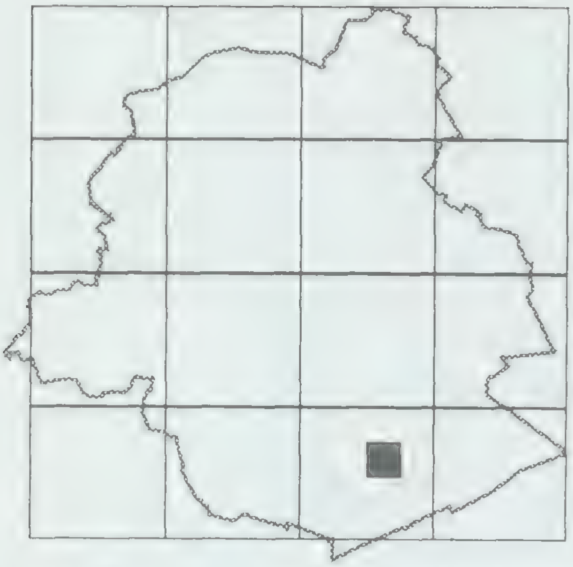
Map 45 Amblystegium riparium



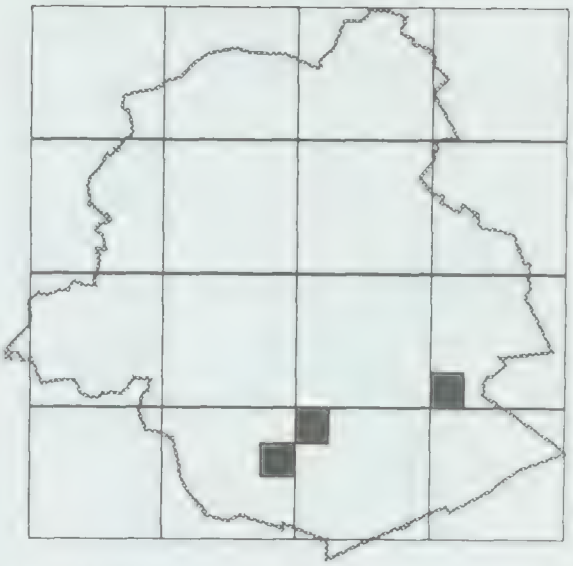
Map 46 Amblystegium serpens



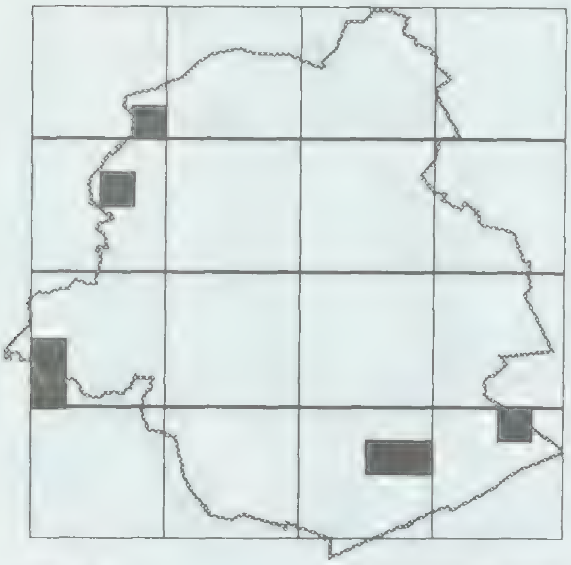
Map 47 Amblystegium tenax



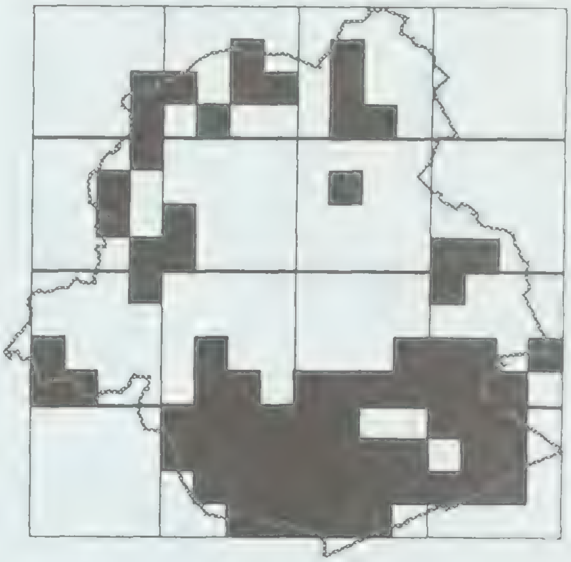
Map 48 Amblystegium varium



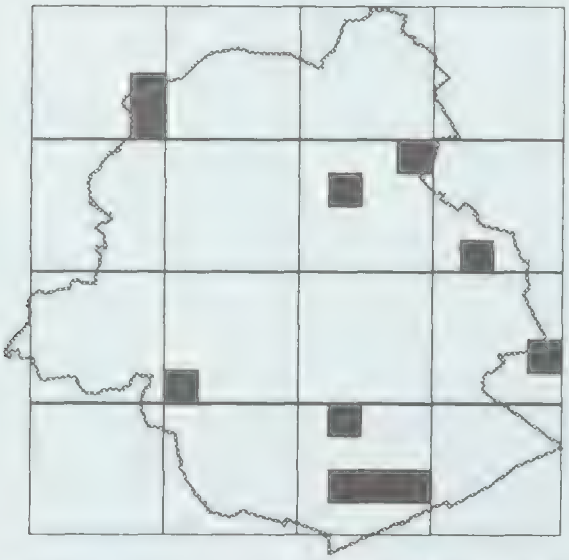
Map 49 Anomodon viticulosus



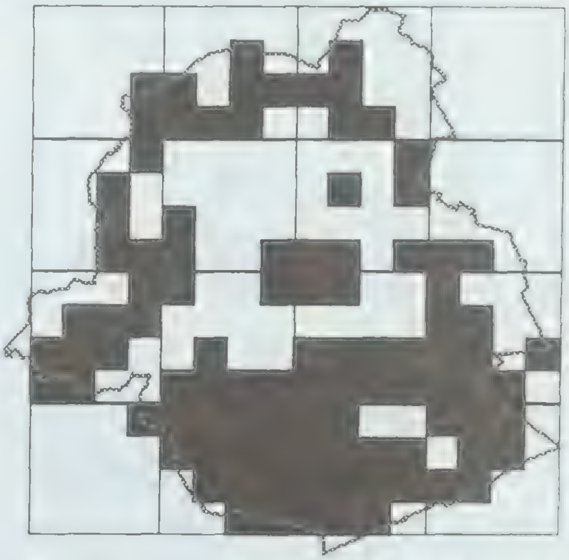
Map 50 Aphanorhegma patens



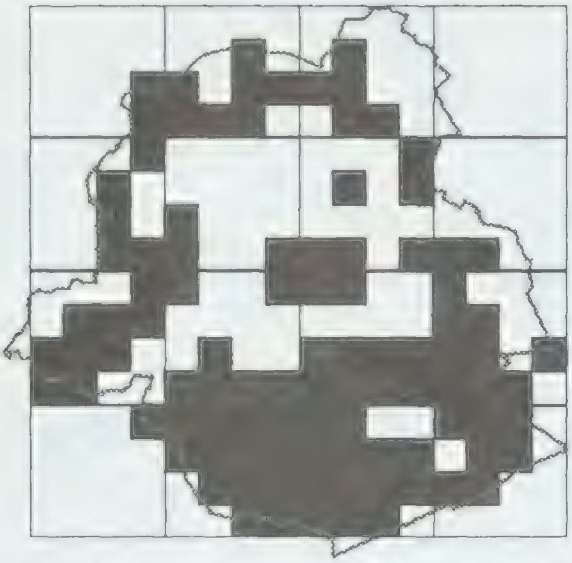
map 51 Atrichum undulatum



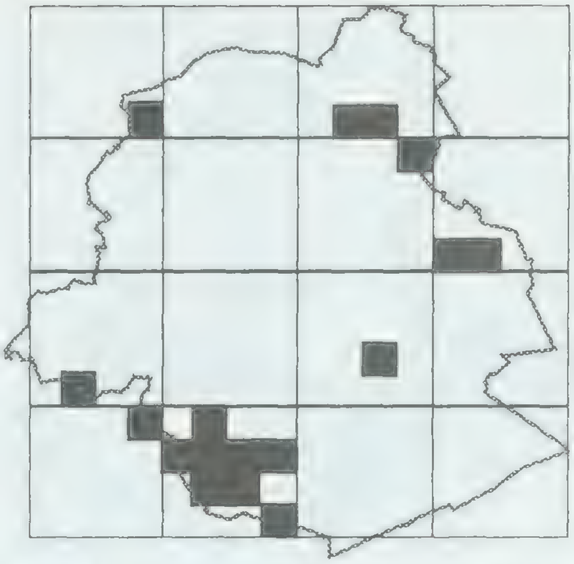
Map 52 Aulacomnium androgynum



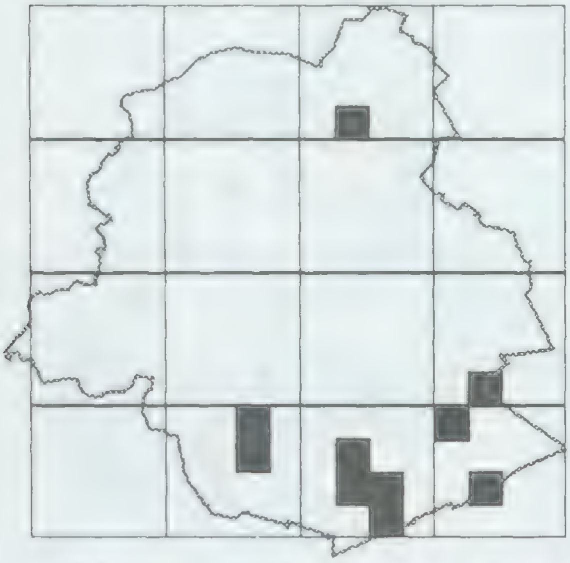
Map 53 Barbula convoluta



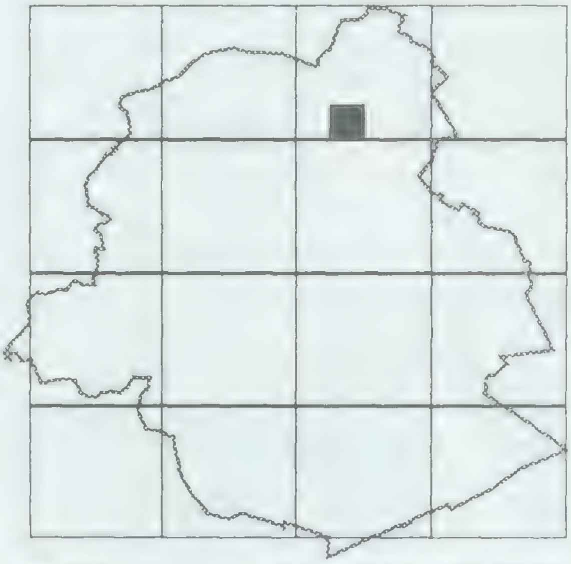
Map 54 Barbula unguiculata



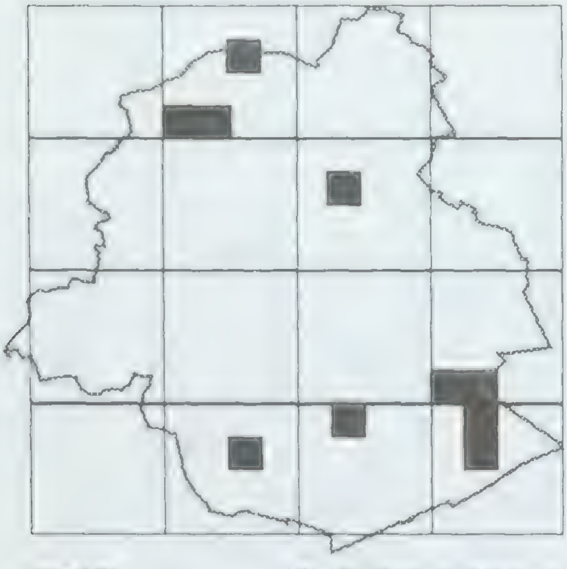
map 55 Brachythecium albicans



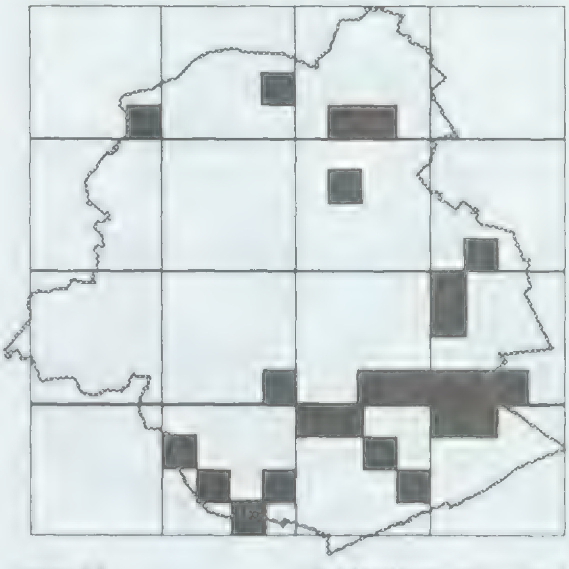
Map 56 Brachythecium glareosum



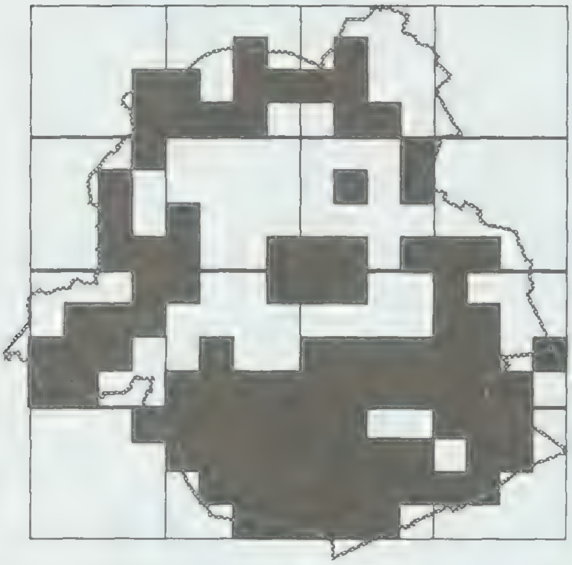
Map 57 Brachythecium mildeanum



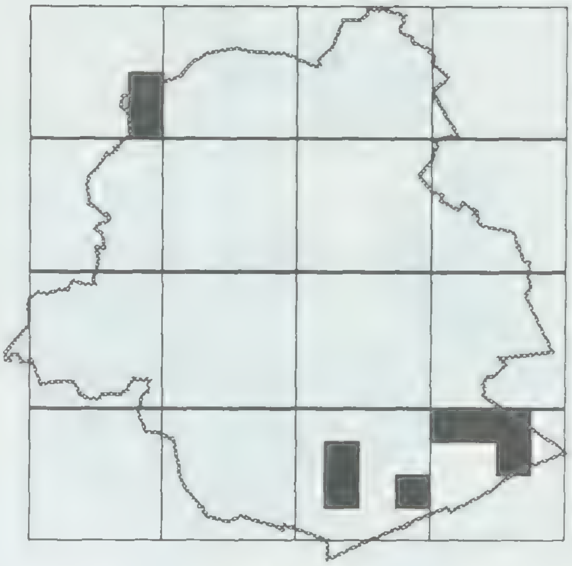
Map 58 Brachythecium populeum



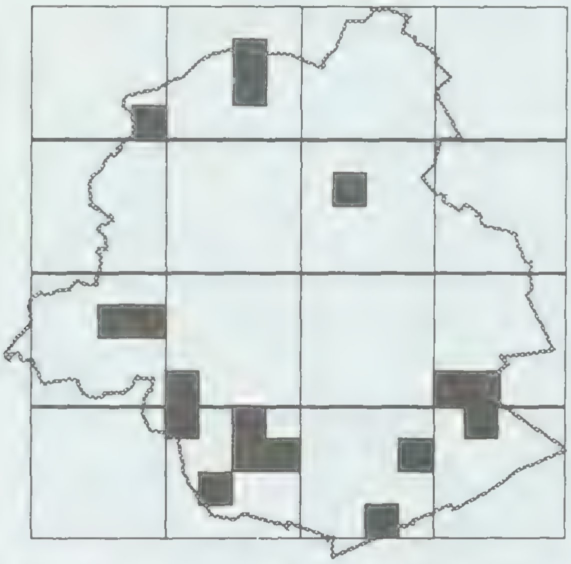
Map 59 Brachythecium rivulare



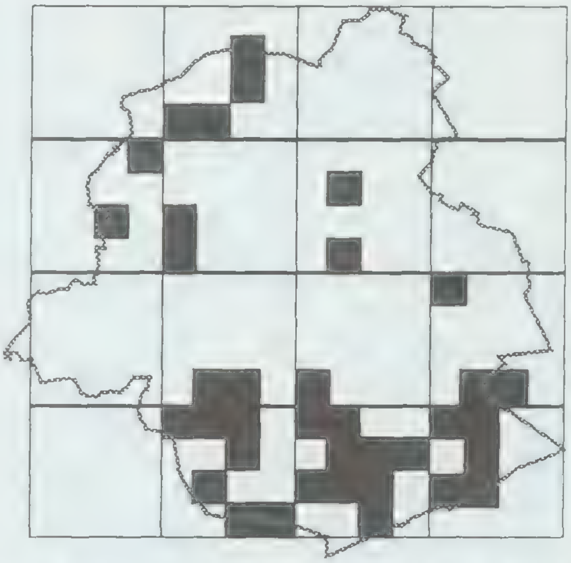
Map 60 Brachythecium rutabulum



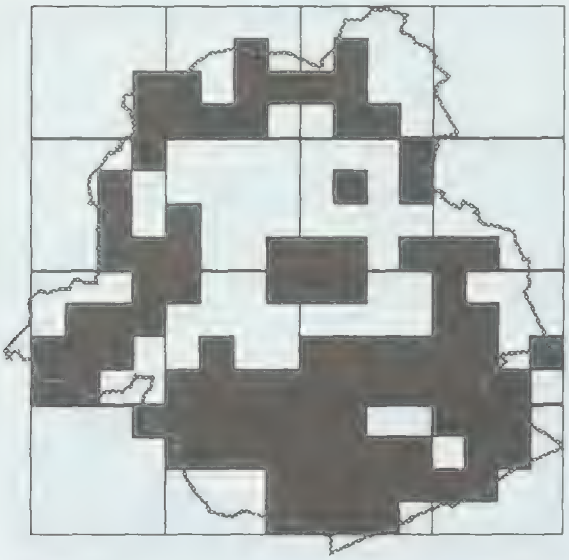
Map 61 Brachythecium salebrosum



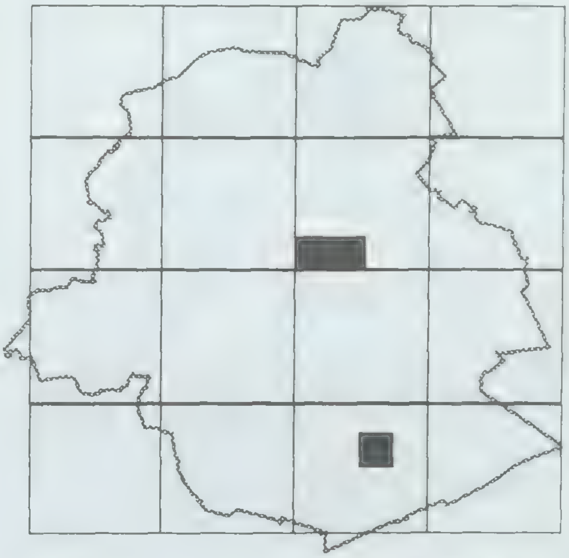
Map 62 Brachythecium velutinum



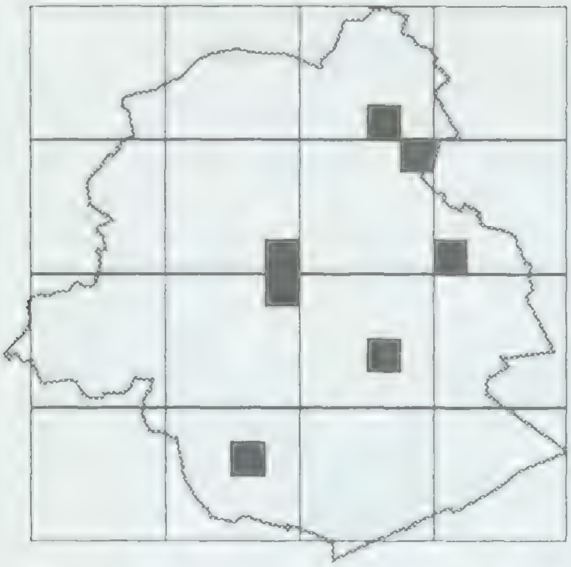
Map 63 Bryoerythrophyllum recurvirostre



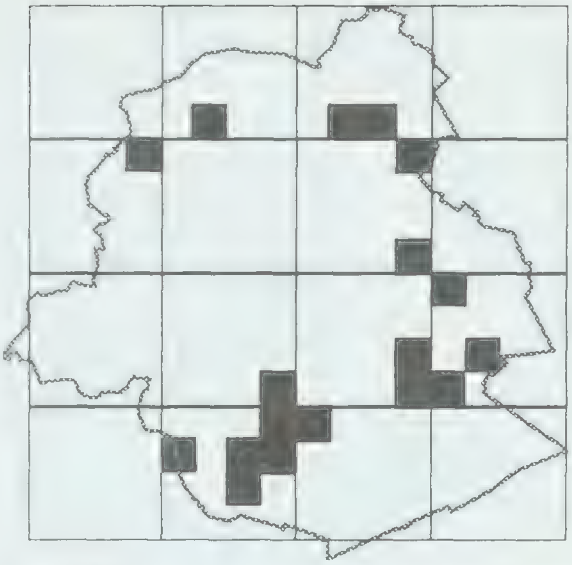
Map 64 Bryum argenteum



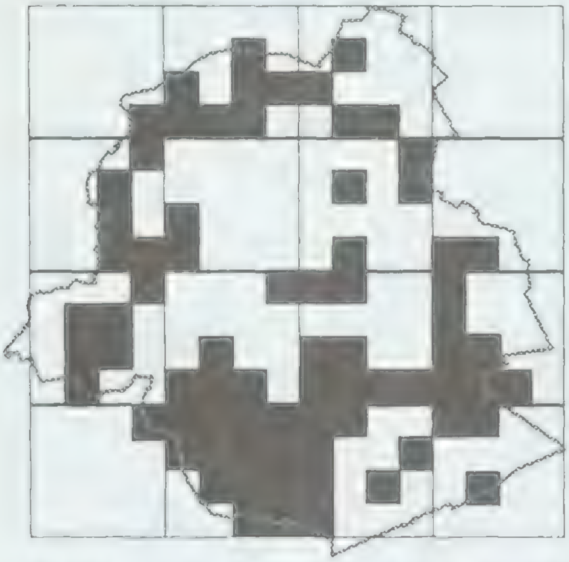
Map 65 Bryum barnesi



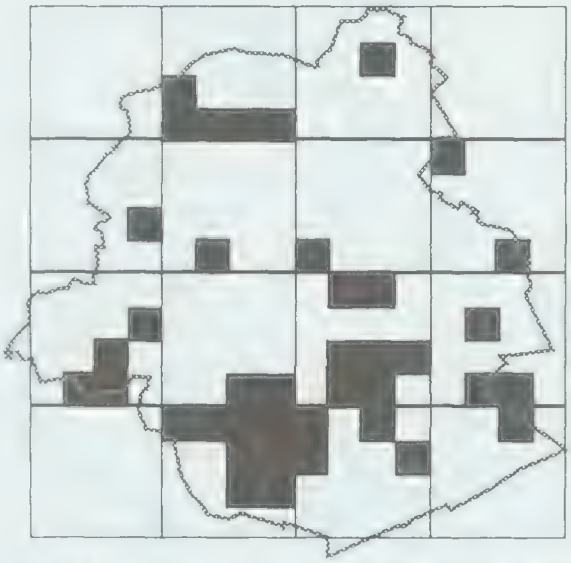
Map 66 Bryum bicolor



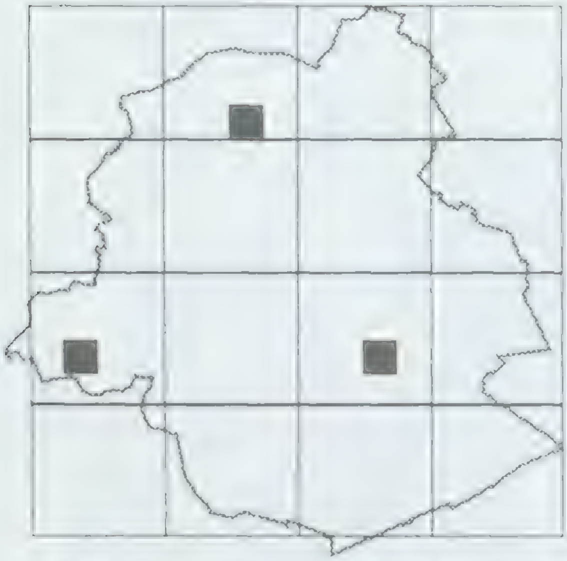
Map 67 Bryum caespiticium



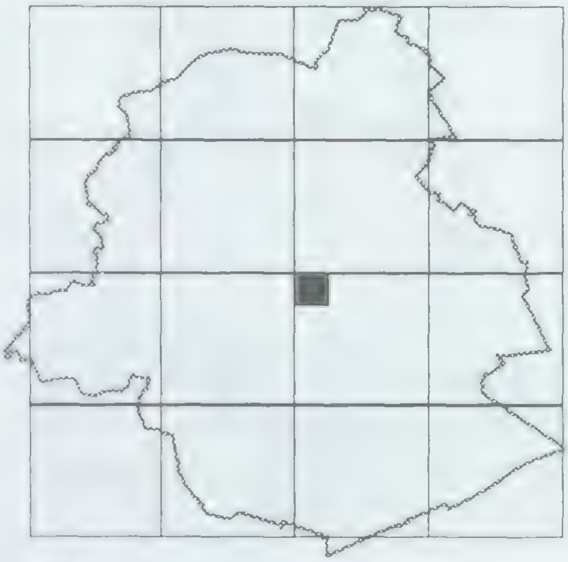
Map 68 Bryum capillare



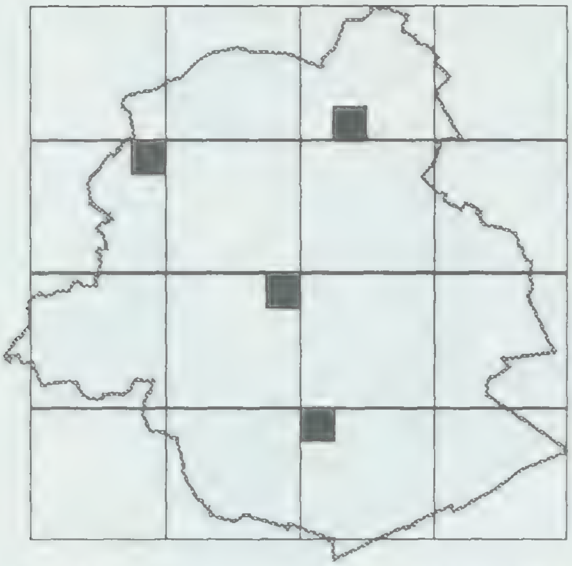
Map 69 Bryum gemmiferum



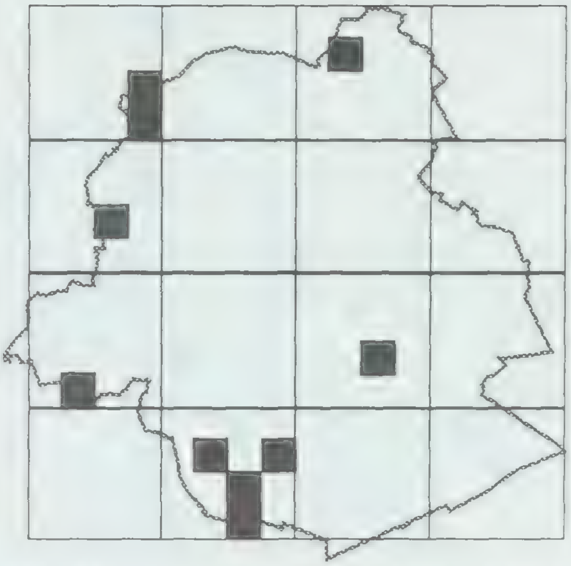
Map 70 Bryum klinggraeffii



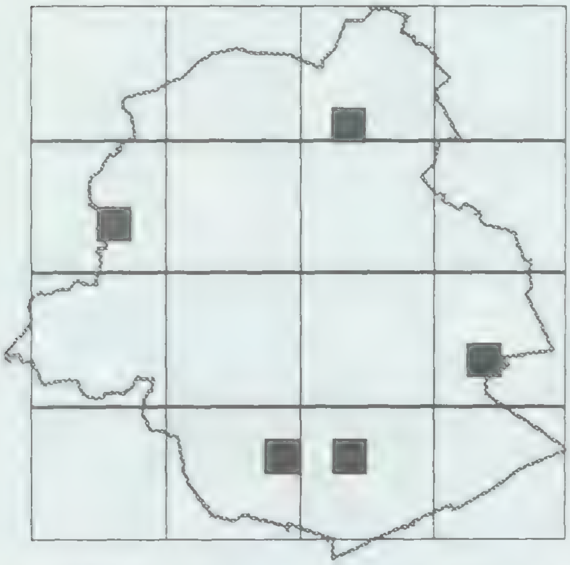
Map 71 Bryum pseudotriquetrum



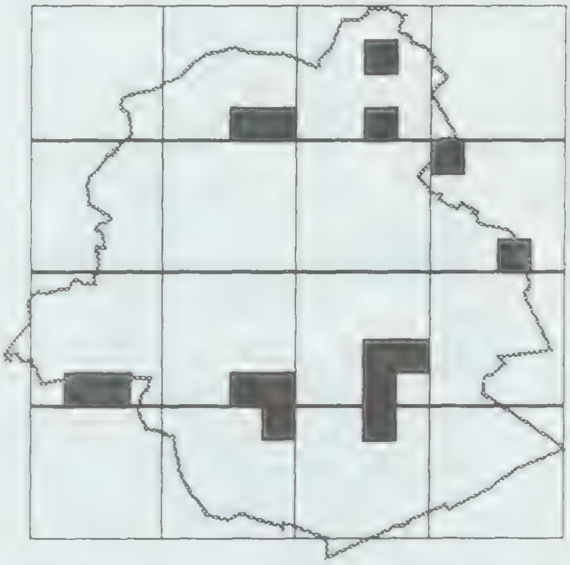
Map 72 Bryum radiculosum



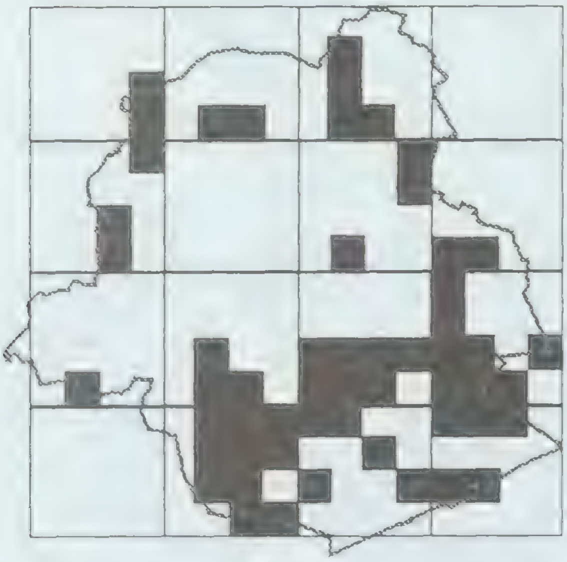
Map 73 Bryum rubens



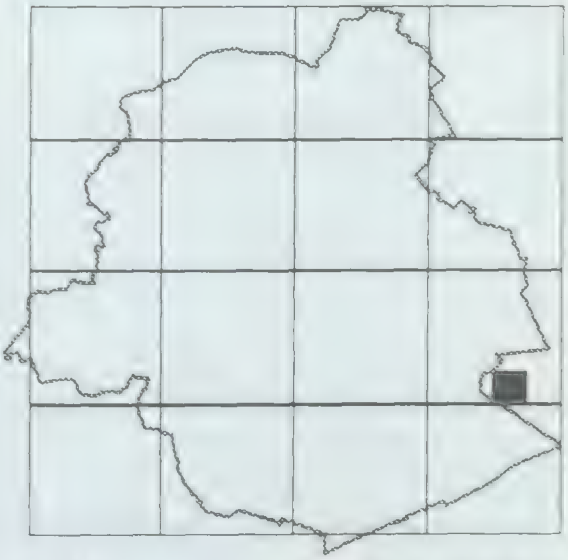
Map 74 Bryum ruderale



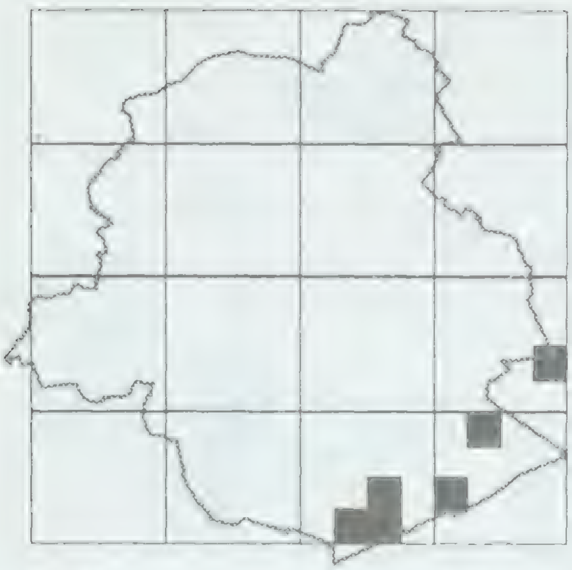
Map 75 Bryum subapiculatum



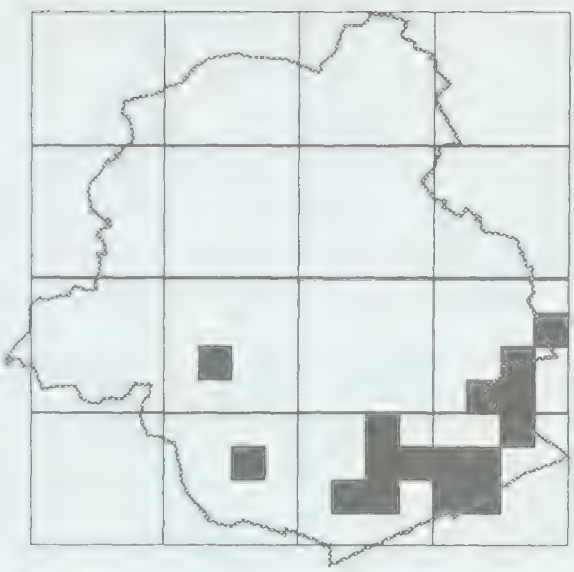
Map 76 Calliergonella cuspidata



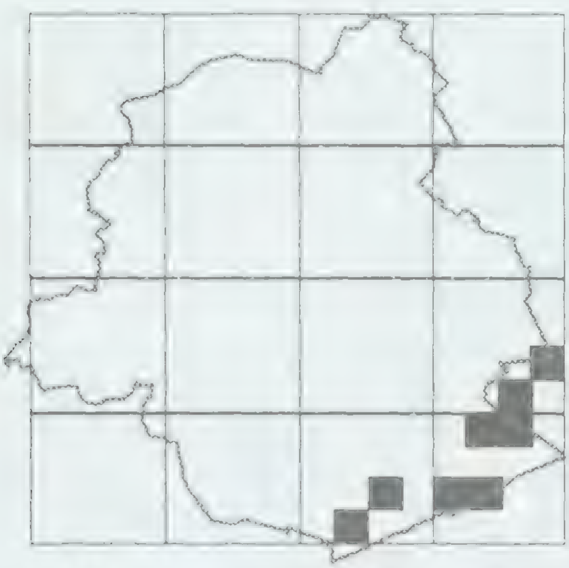
Map 77 Campylium chrysophyllum



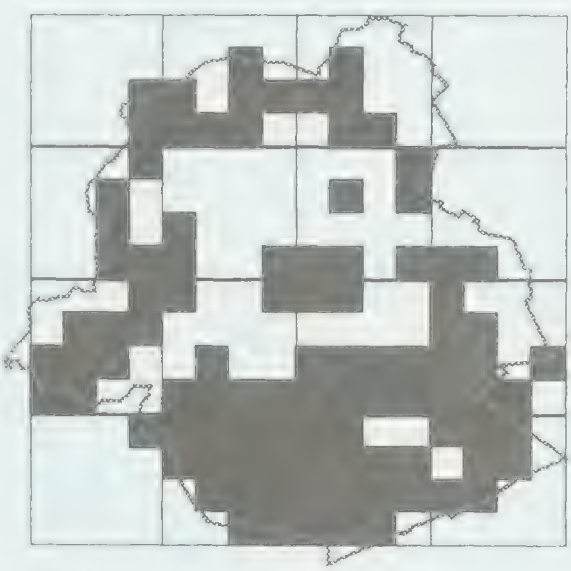
Map 78 Campylopus flexuosus



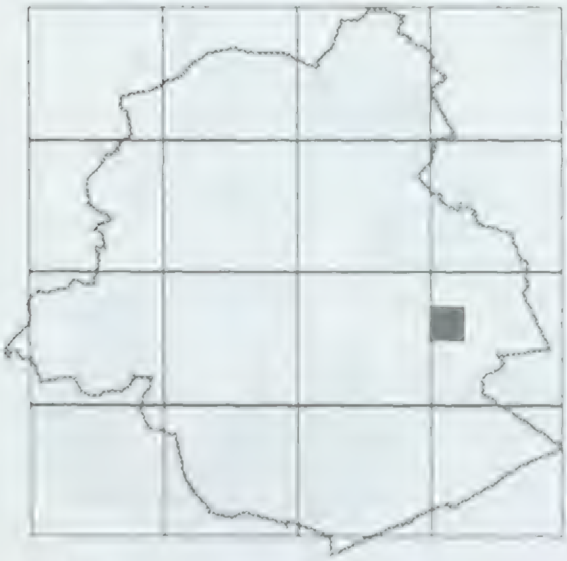
Map 79 Campylopus introflexus



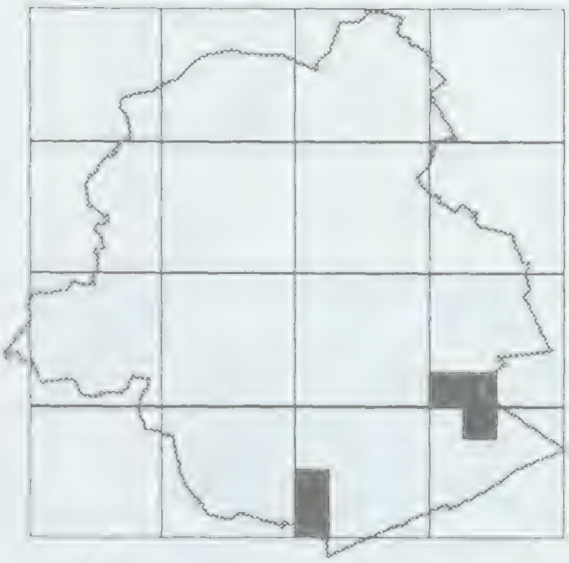
Map 80 Campylopus pyriformis



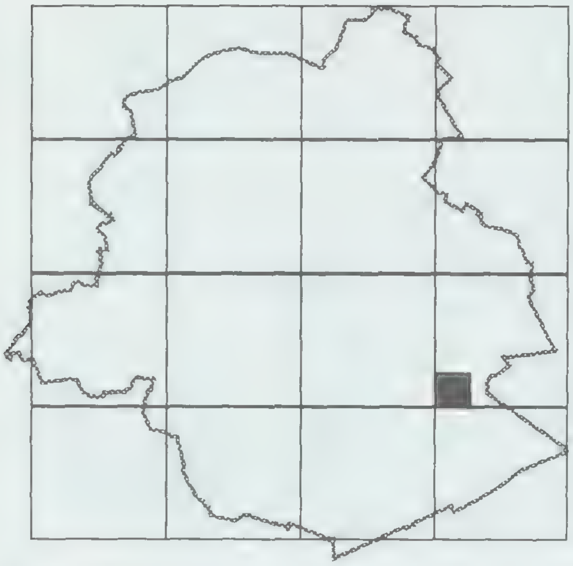
Map 81 Ceratodon purpureus



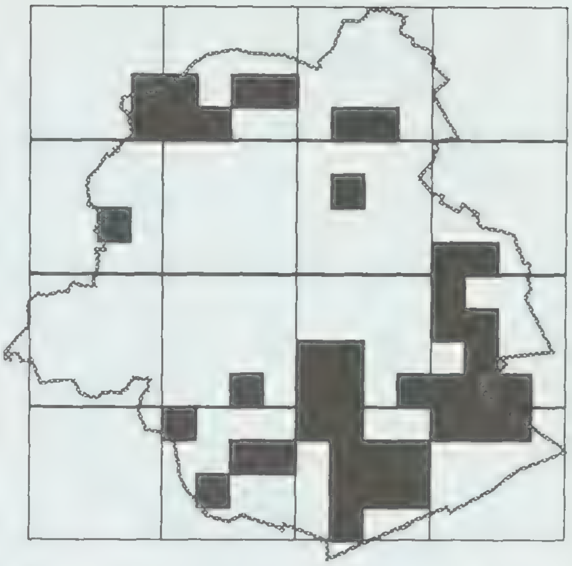
Map 82 Cinclidotus fontinaloides



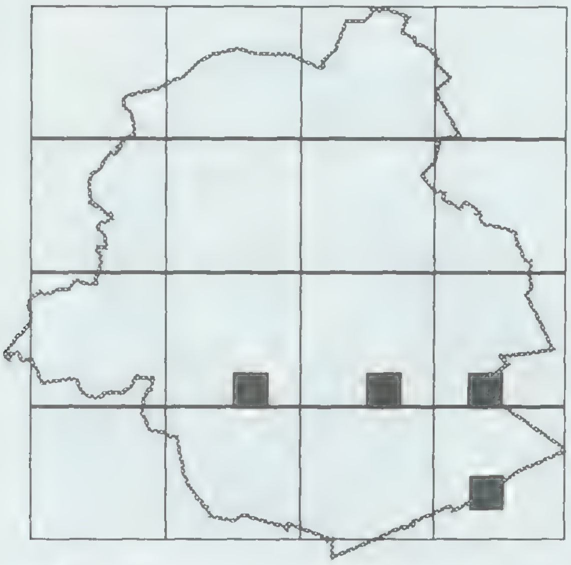
Map 83 Cirriphyllum piliferum



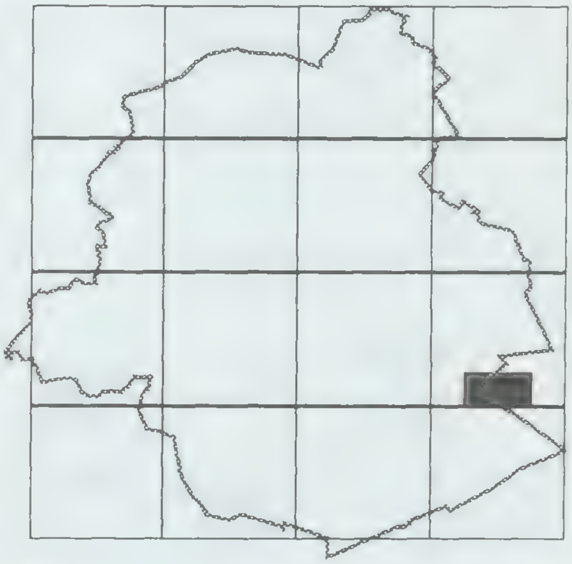
Map 84 Climacium dendroides



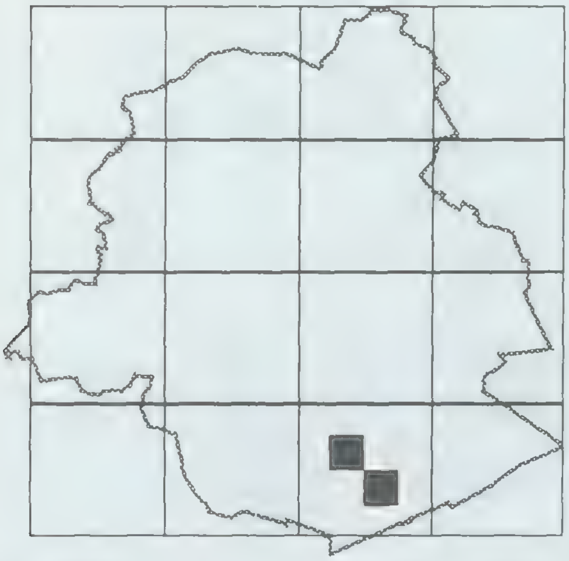
Map 85 Cratoneuron filicinum



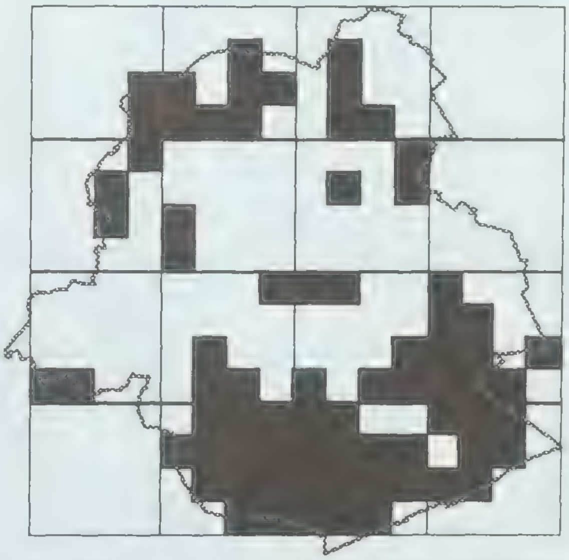
Map 86 Cryphaea heteromalla



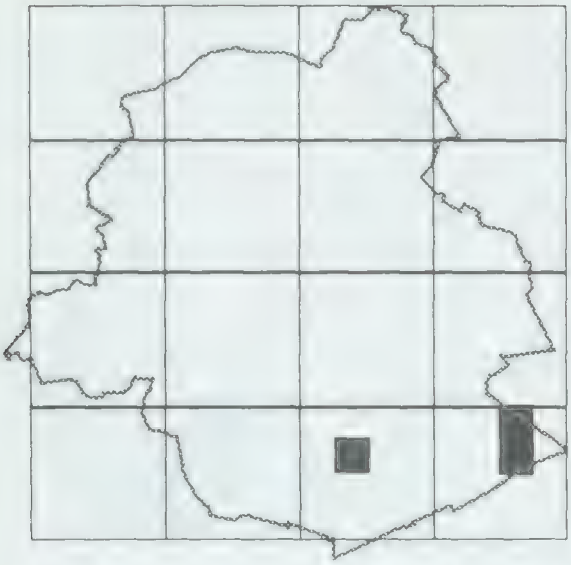
Map 87 Ctenidium molluscum



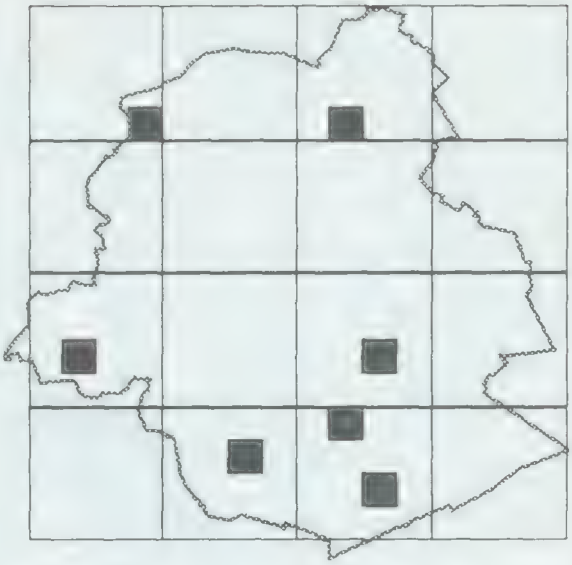
Map 88 Dichodontium pellucidum



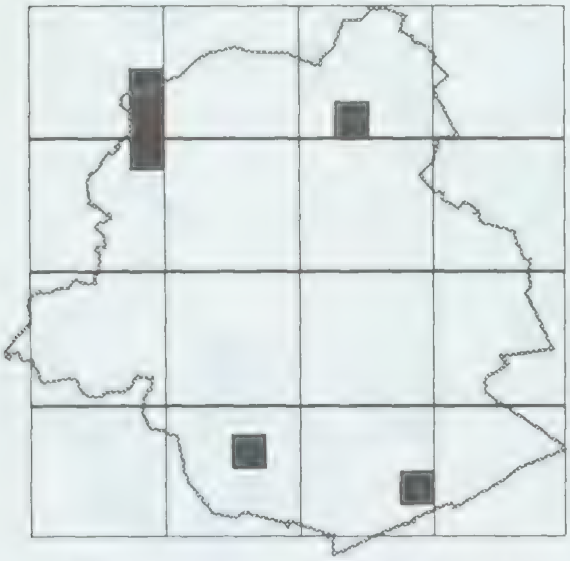
Map 89 Dicranella heteromalla



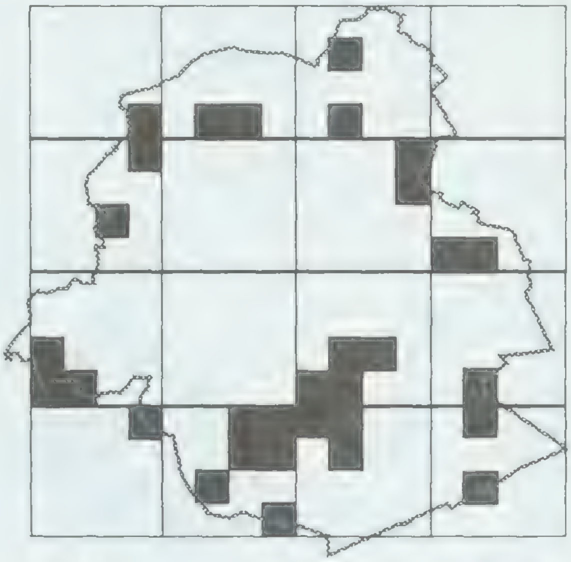
Map 90 Dicranella rufescens



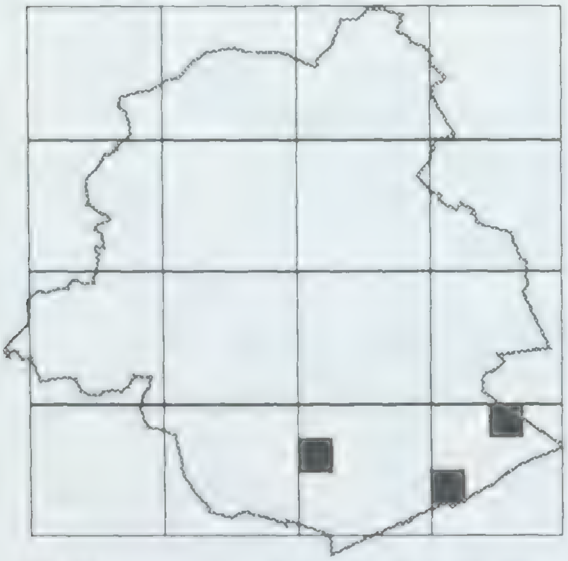
Map 91 Dicranella schreberiana



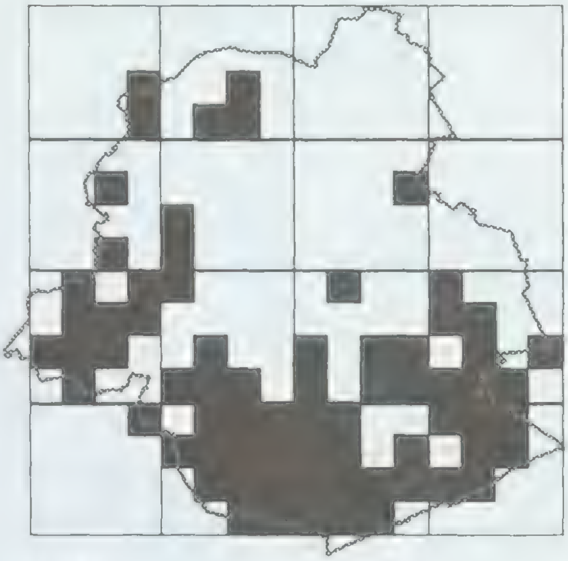
Map 92 Dicranella staphylina



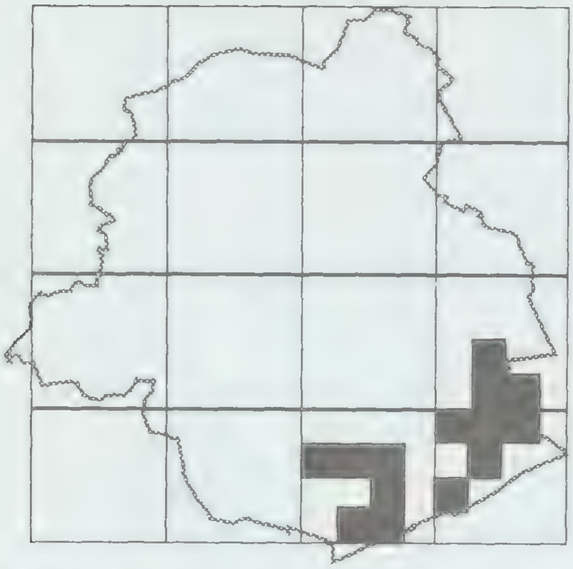
Map 93 Dicranella varia



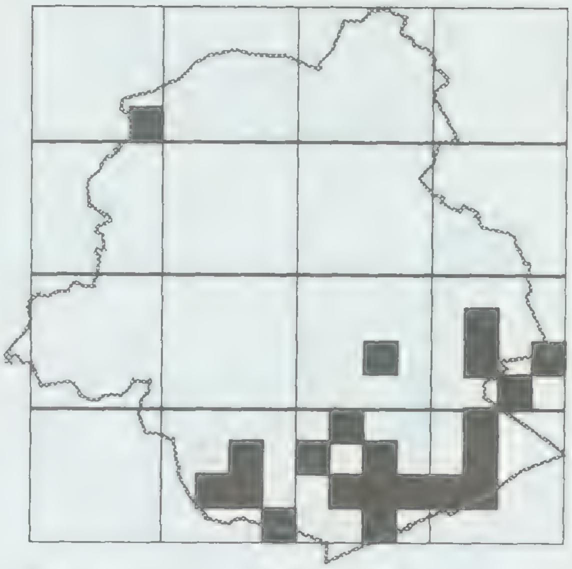
Map 94 Dicranodontium denudatum



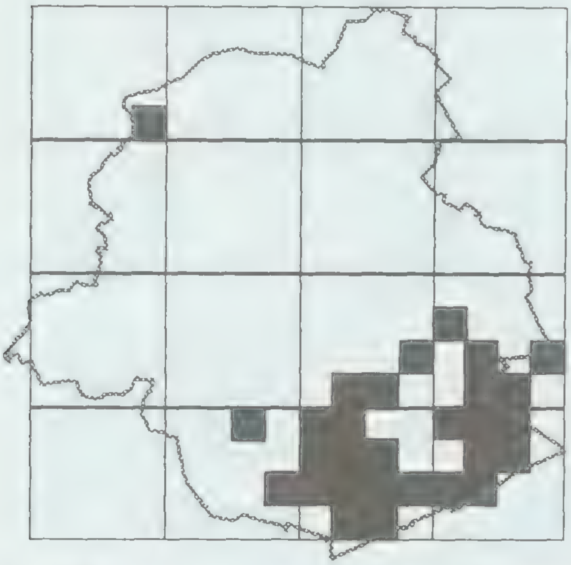
Map 95 Dicranoweisia cirrata



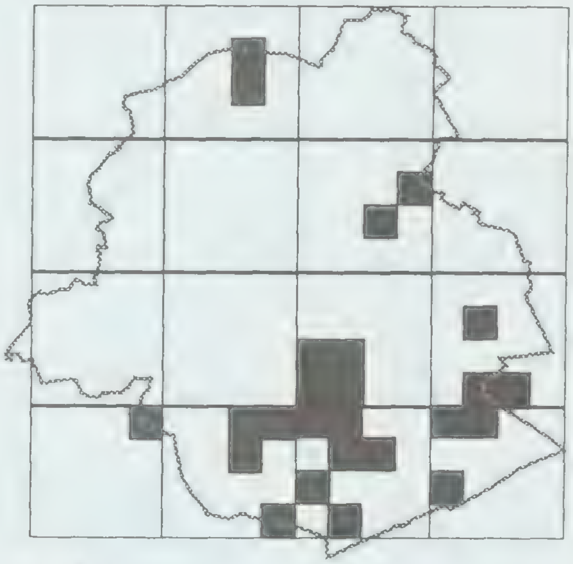
Map 96 Dicranum montanum



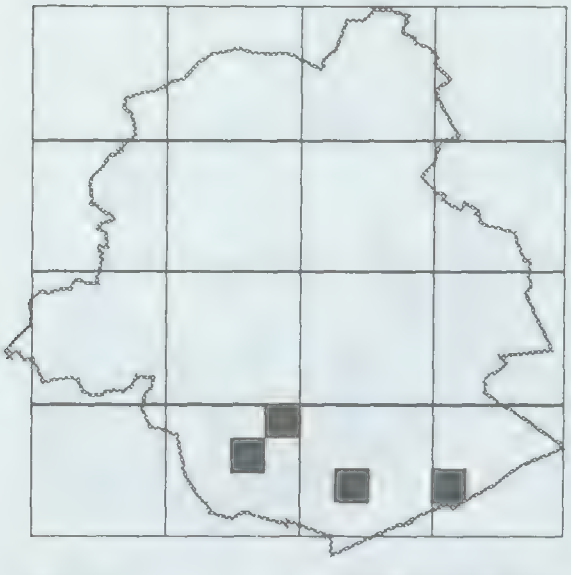
Map 97 Dicranum scoparium



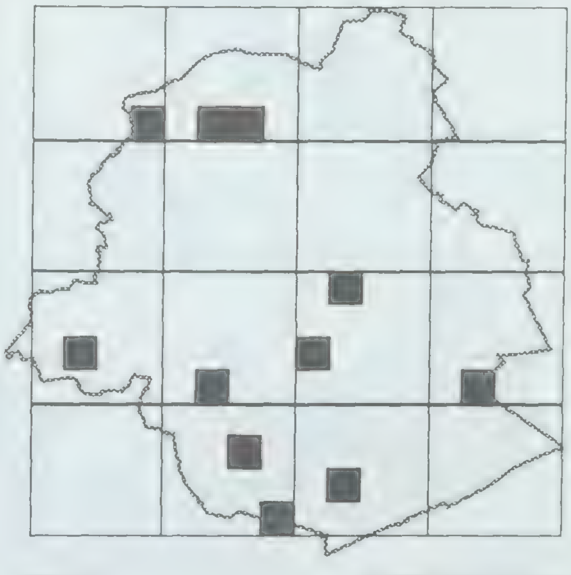
Map 98 Dicranum tauricum



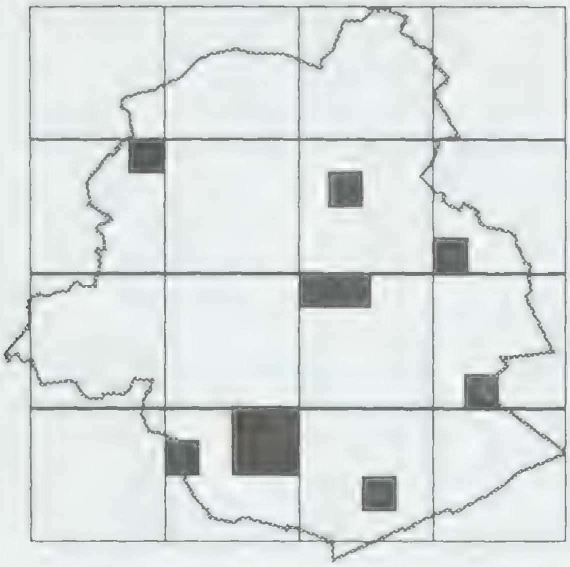
Map 99 Didymodon fallax



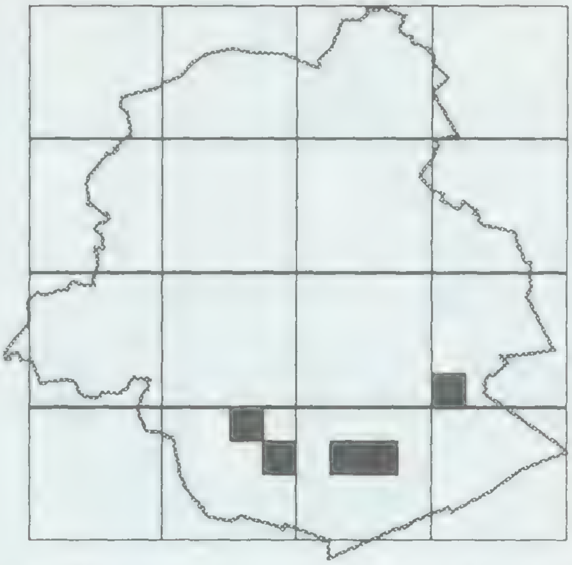
Map 100 Didymodon insulanus



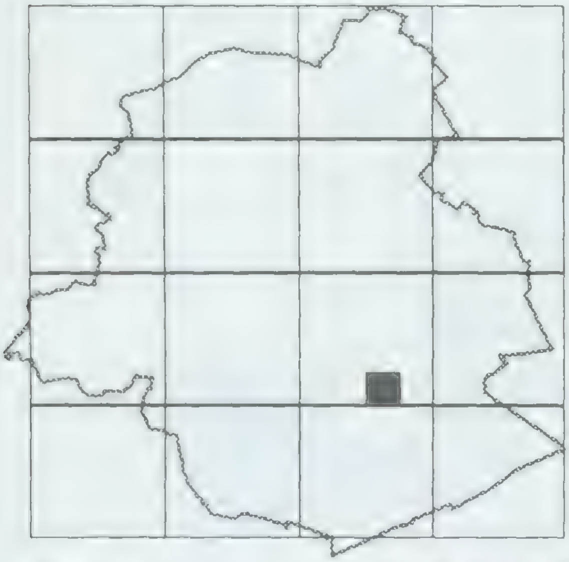
Map 101 Didymodon luridus



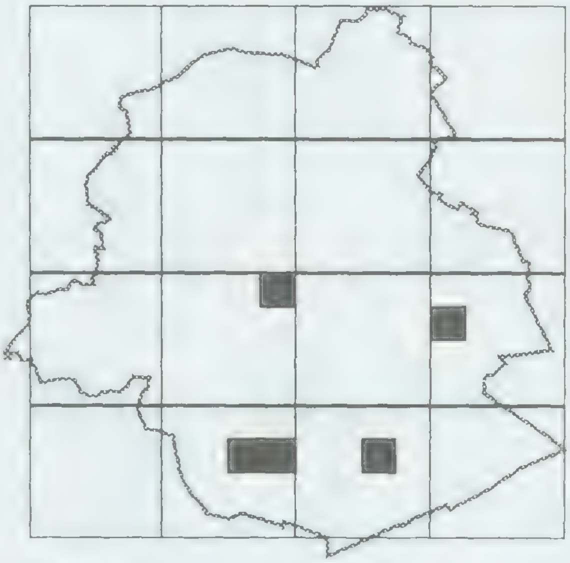
Map 102 Didymodon rigidulus



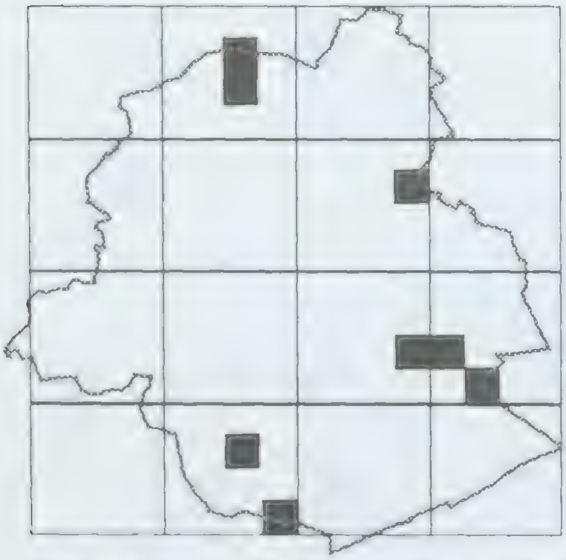
Map 103 Didymodon sinuosus



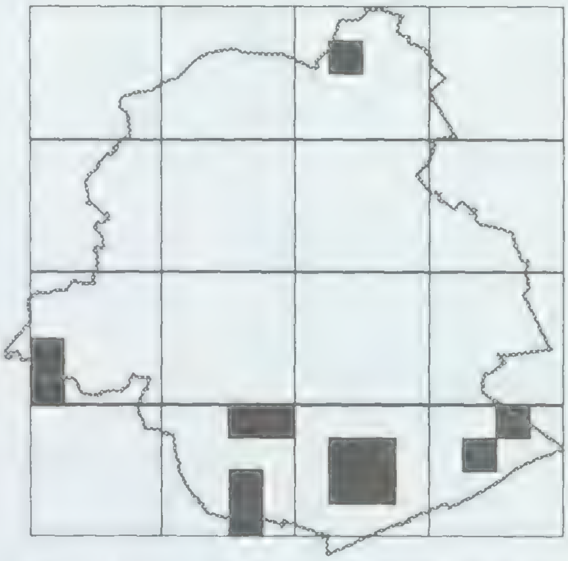
Map 104 Didymodon spadiceus



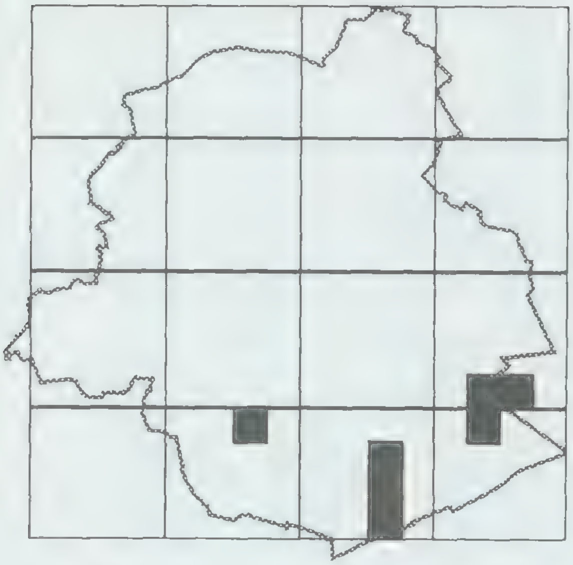
Map 105 Didymodon tophaceus



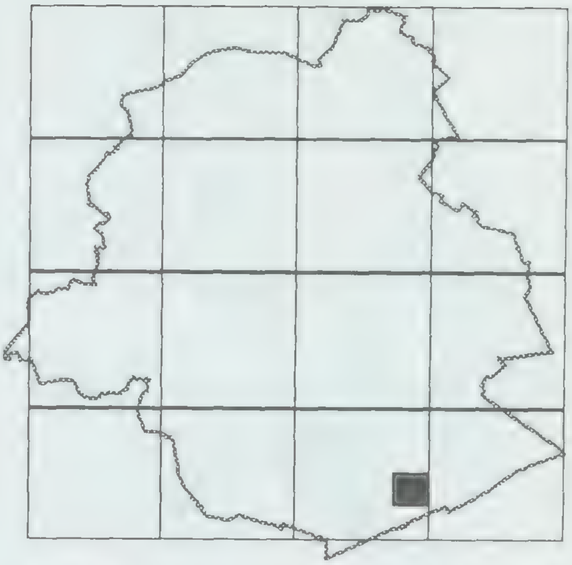
Map 106 Didymodon vinealis



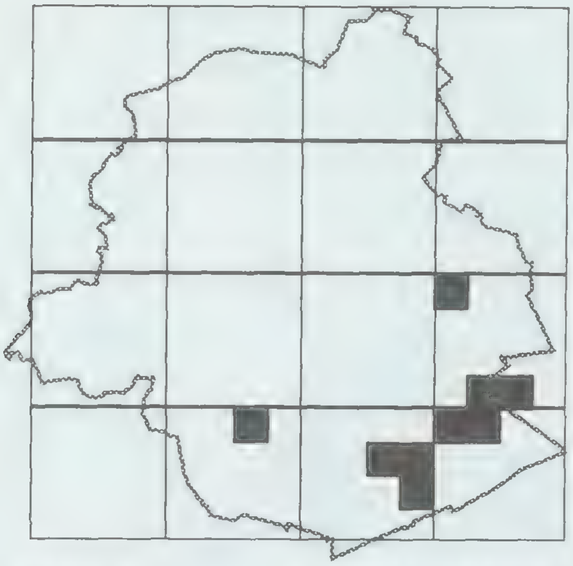
Map 107 Ditrichum cylindricum



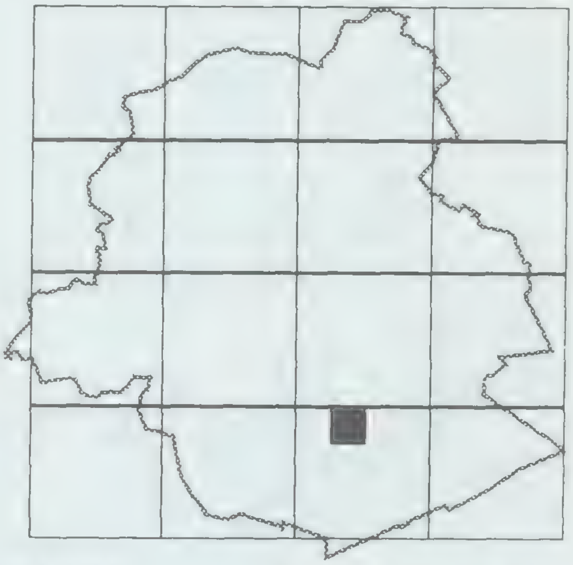
Map 108 Ditrichum heteromallum



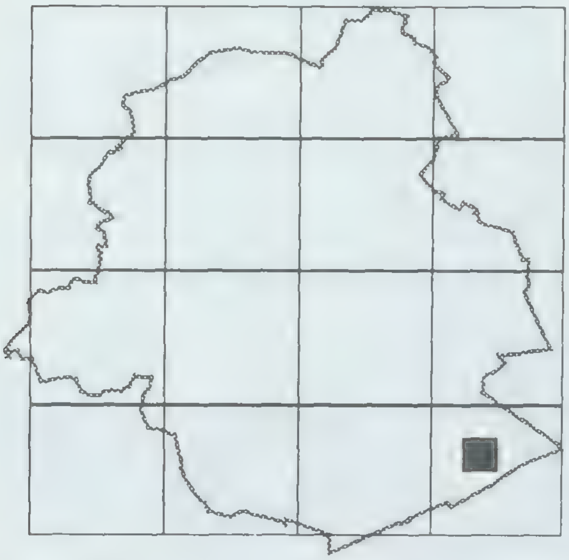
Map 109 Drepanocladus aduncus



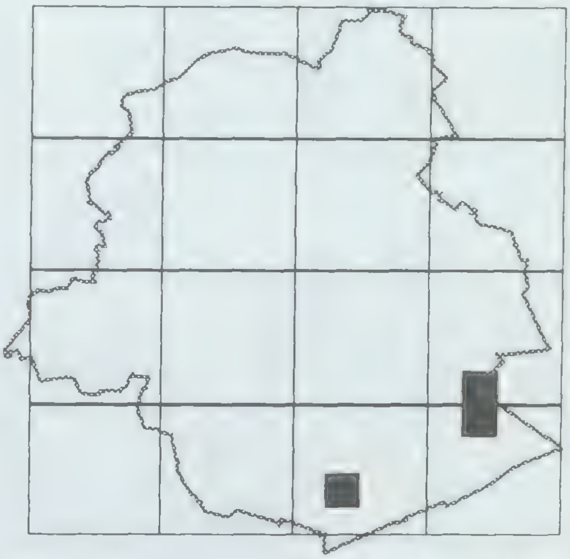
Map 110 Encalypta streptocarpa



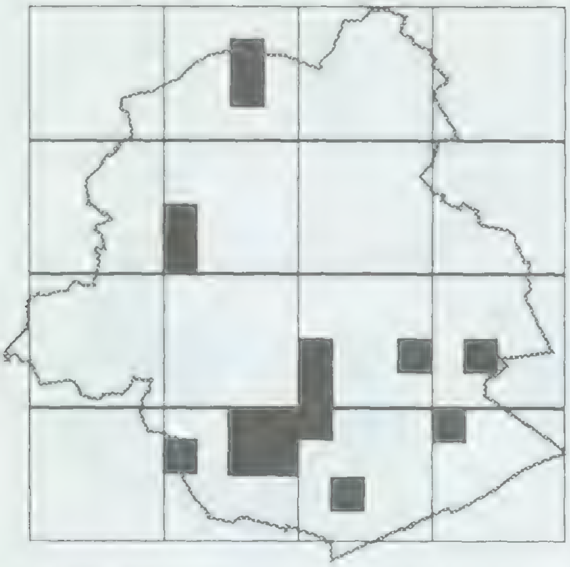
Map 111 Ephemerum minutissimum



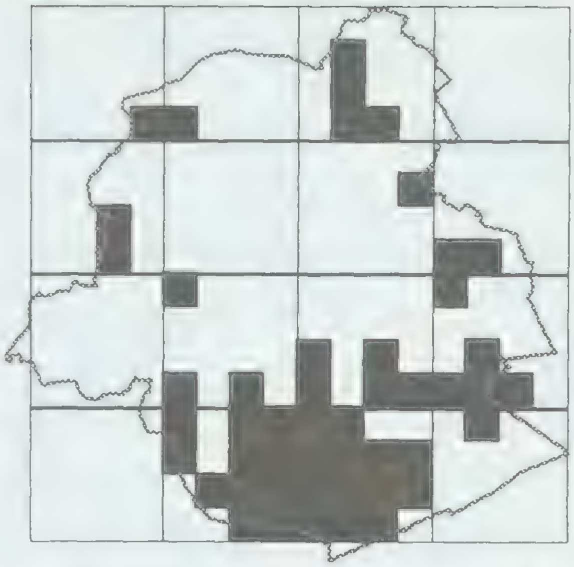
Map 112 Ephemerum stellatum



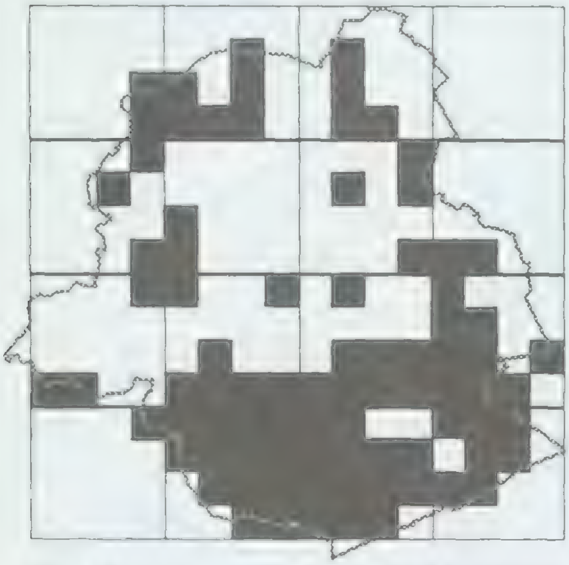
Map113 Eucladium verticillatum



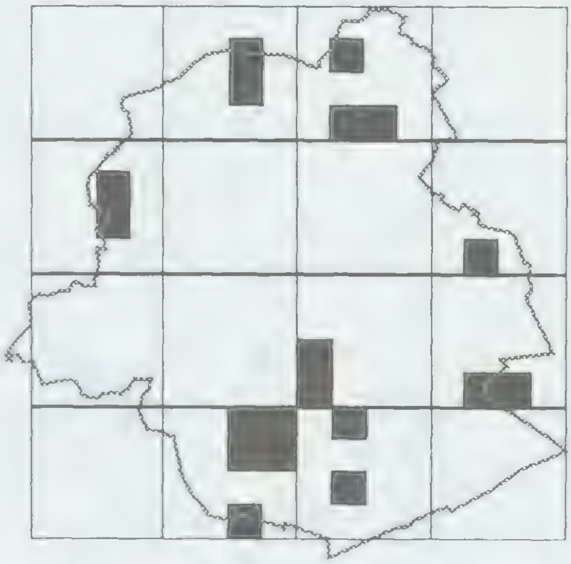
Map 114 Eurhynchium crassinervium



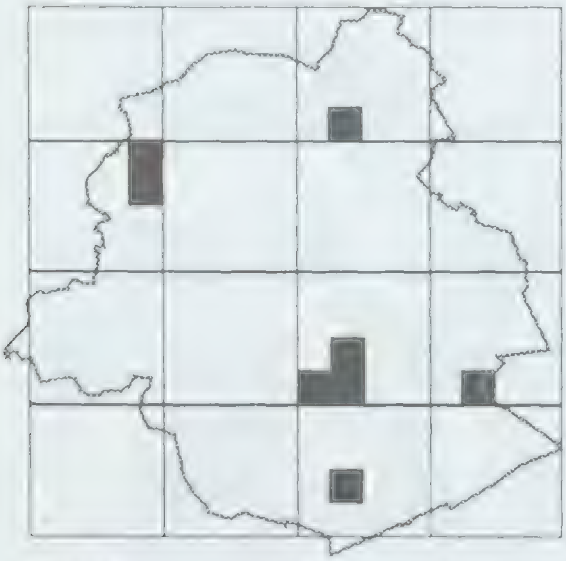
Map 115 Eurhynchium hians



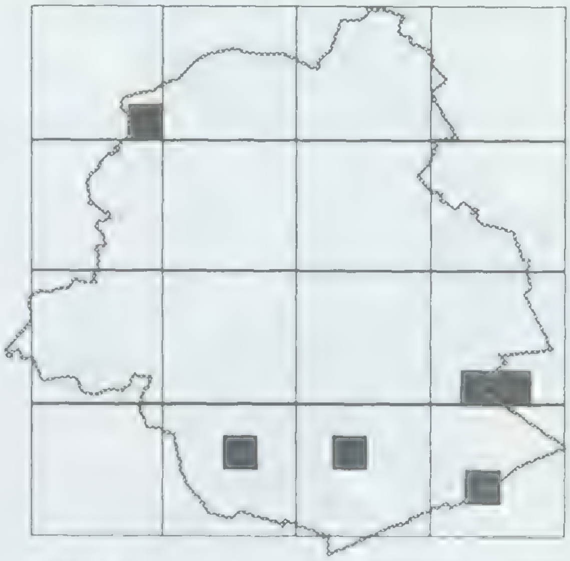
Map 116 Eurhynchium praelongum



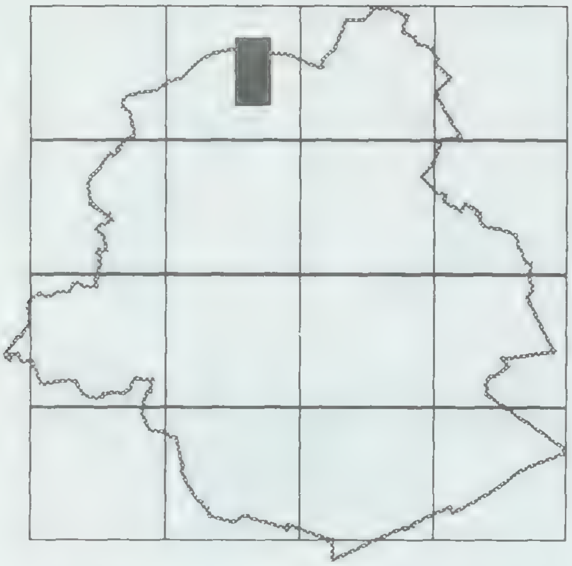
Map 117 Eurhynchium pumilum



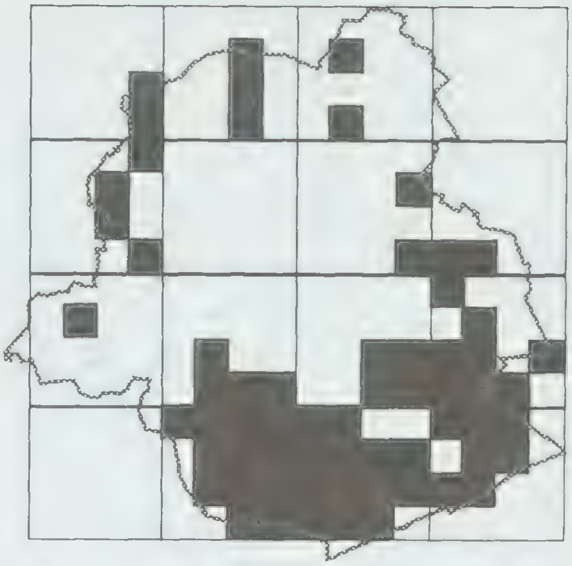
Map 118 Eurhynchium schleicheri



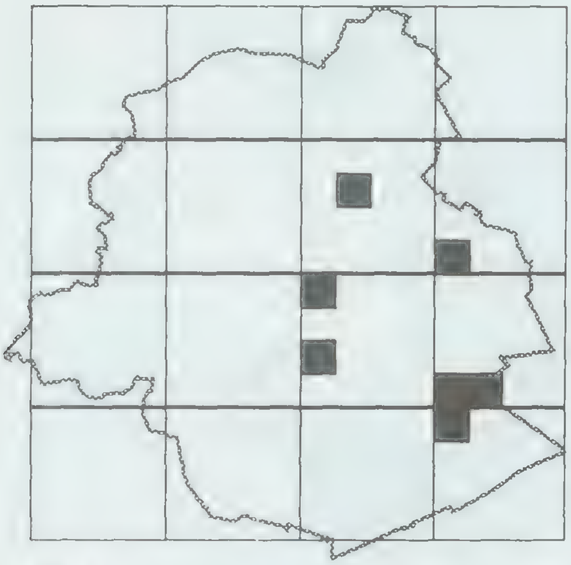
Map 119 Eurhynchium striatum



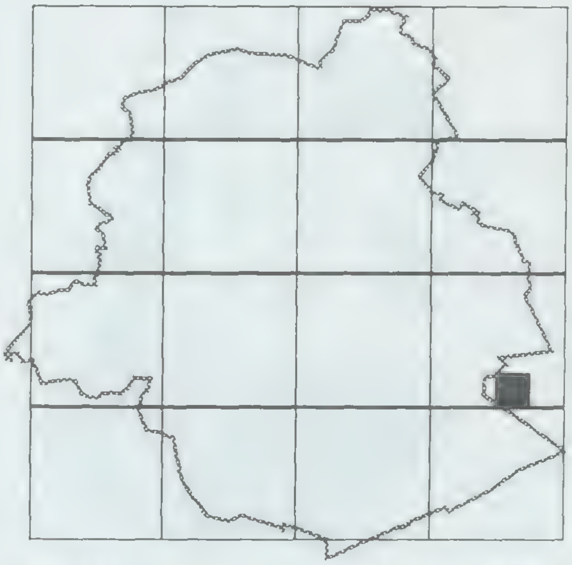
Map 120 Fissidens bambergeri



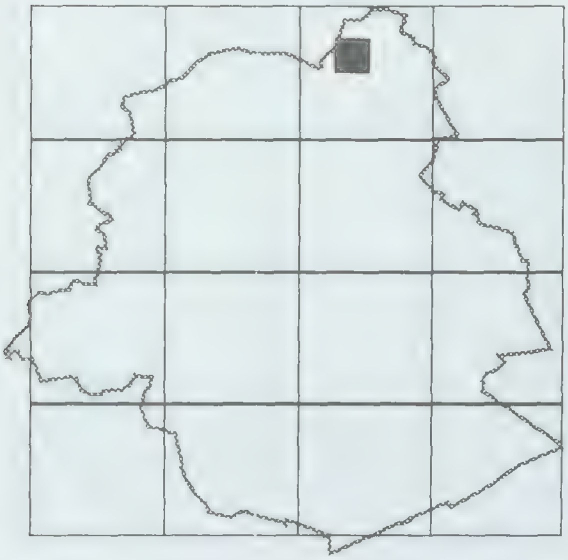
Map 121 Fissidens bryoides



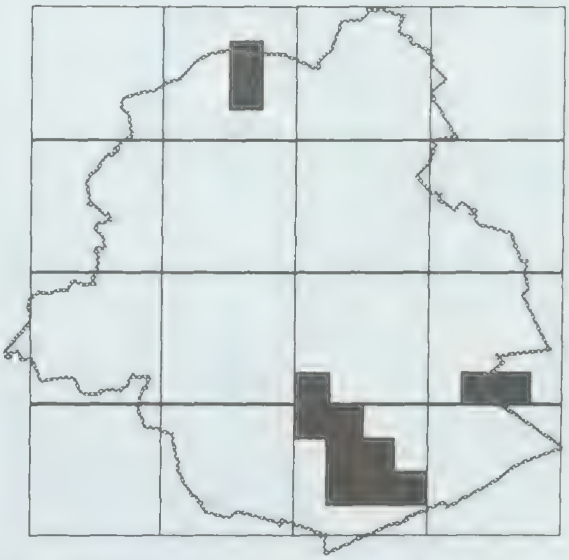
Map 122 Fissidens crassipes



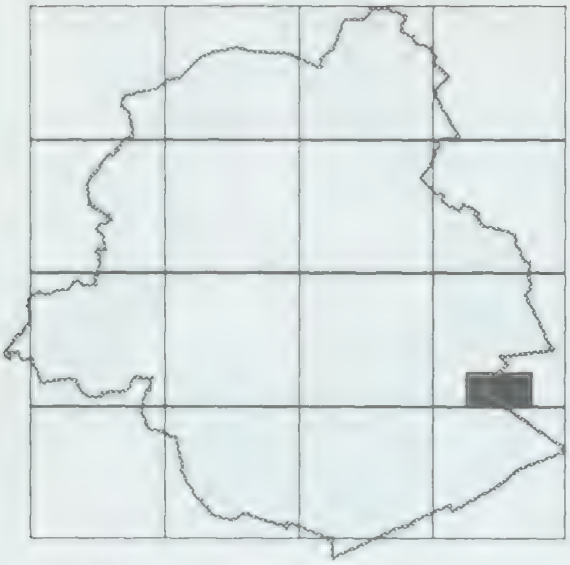
Map 123 Fissidens dubius



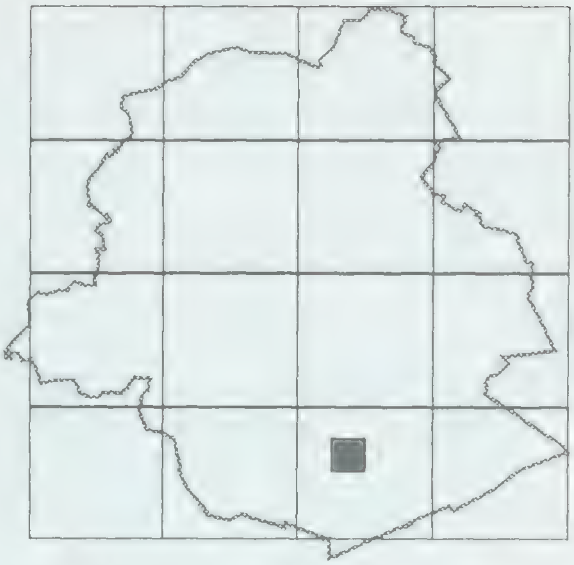
Map 124 Fissidens exilis



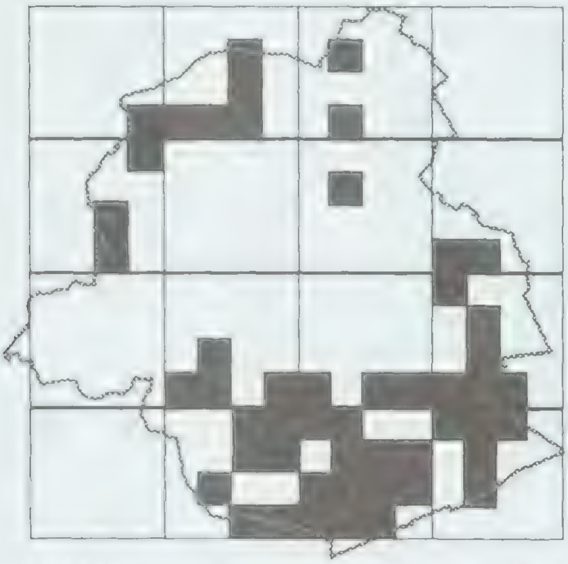
Map 125 Fissidens gracilifolius



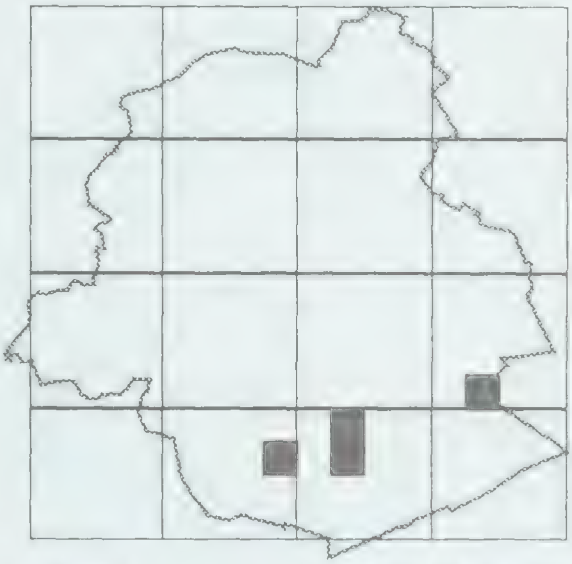
Map 126 Fissidens incurvus



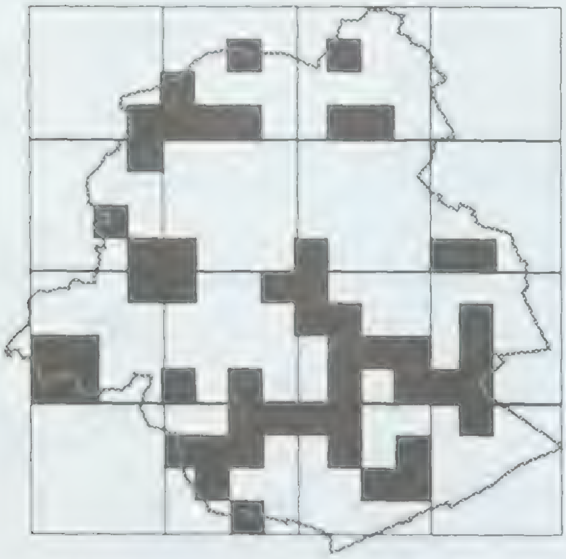
Map 127 Fissidens pusillus



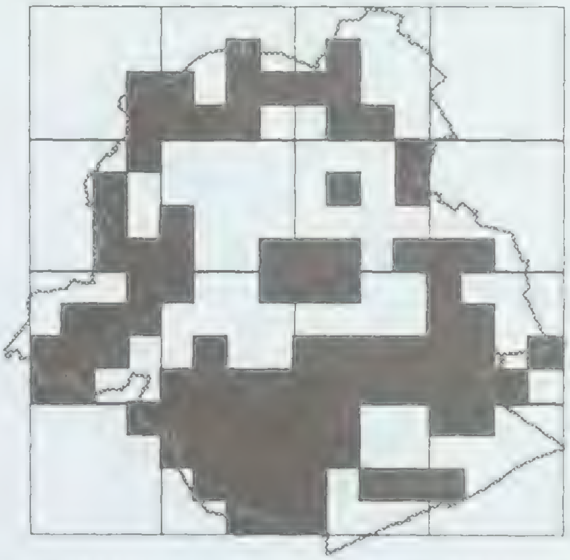
Map 128 Fissidens taxifolius



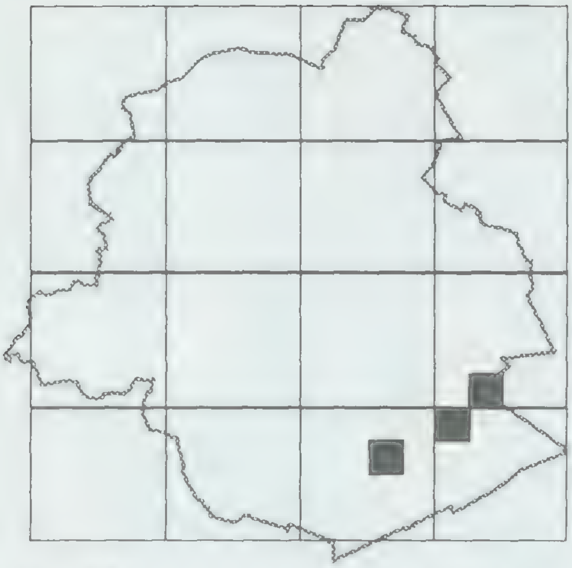
Map 129 Fissidens viridulus



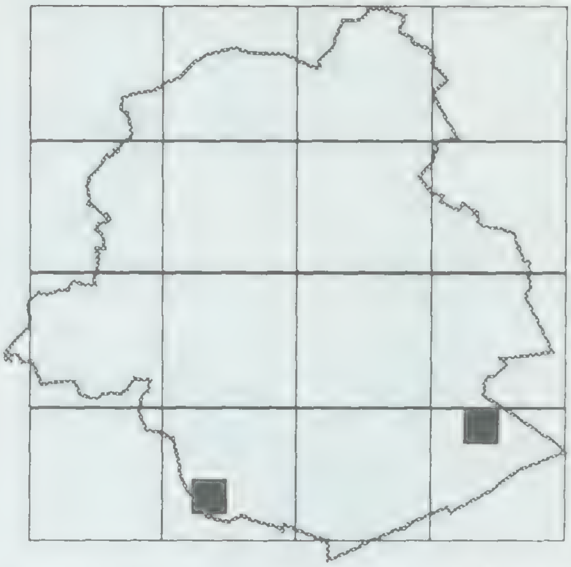
Map 130 Funaria hygrometrica



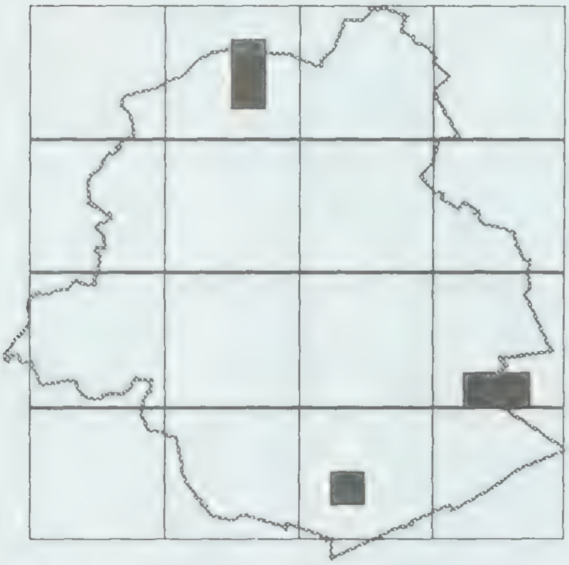
Map 131 Grimmia pulvinata



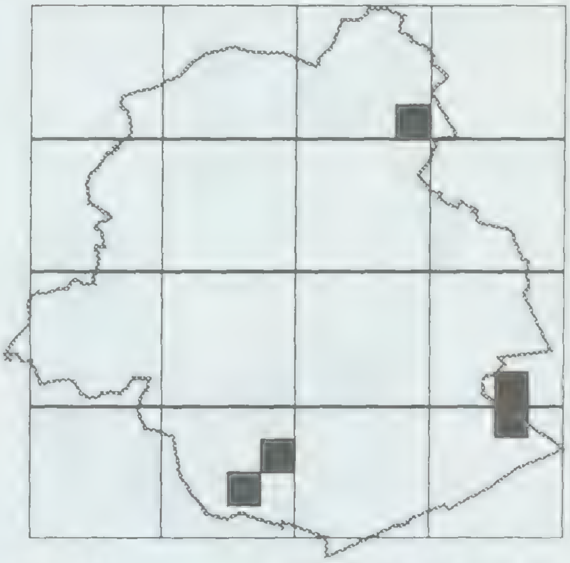
Map 132 Gyroweisia tenuis



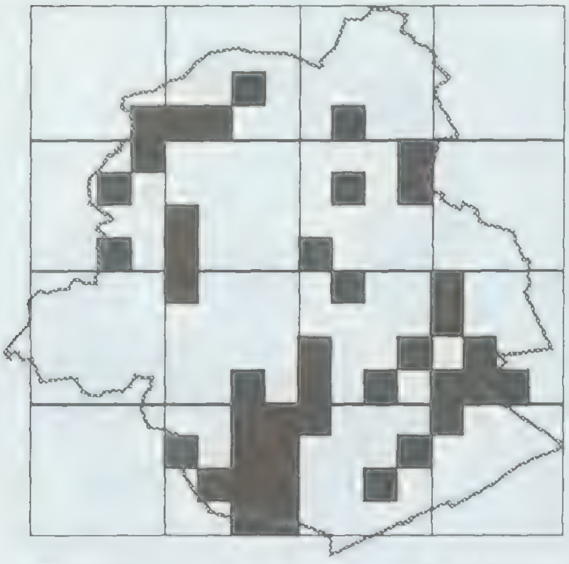
Map 133 Herzogiella seligeri



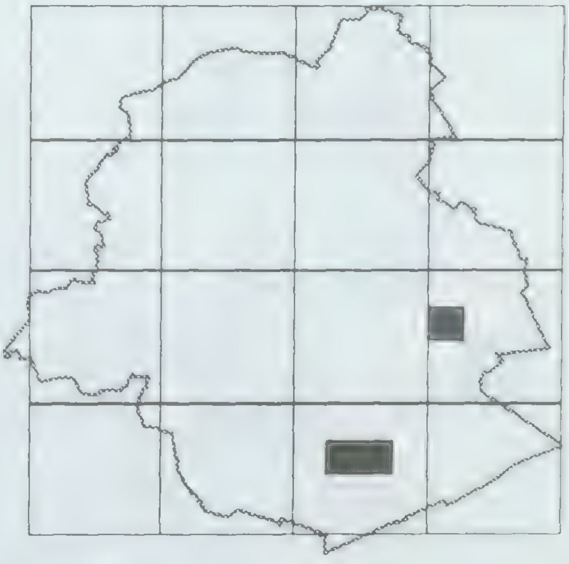
Map 134 Homalia trichomanoides



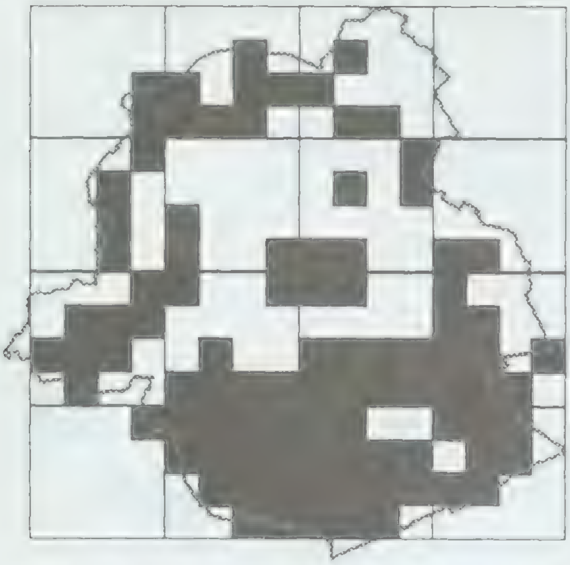
Map 135 Homalothecium lutescens



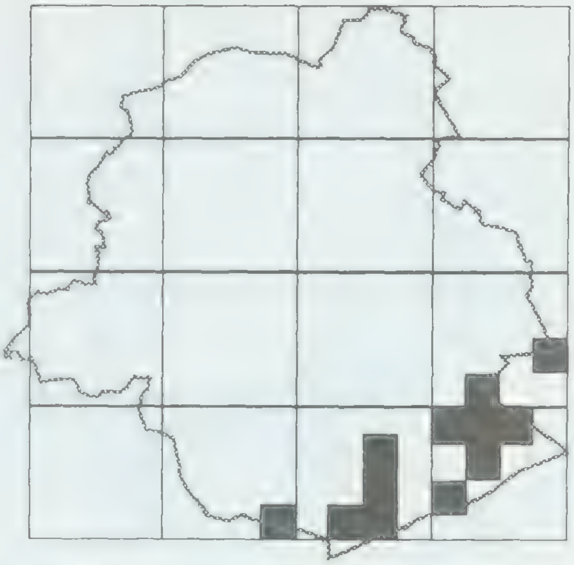
Map 136 Homalothecium sericeum



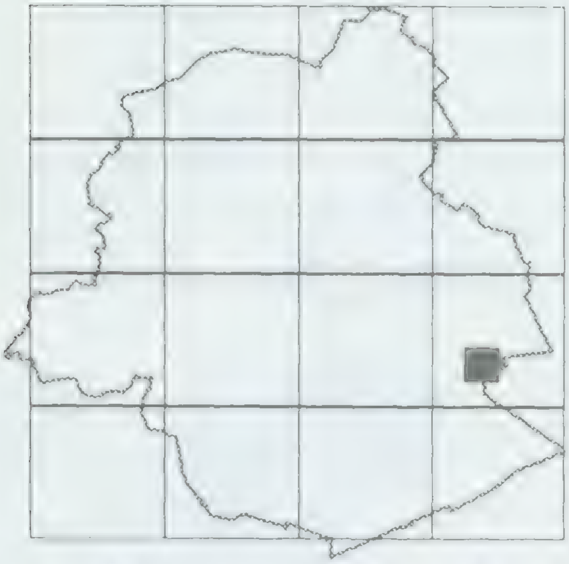
Map 137 Hygrohypnum luridum



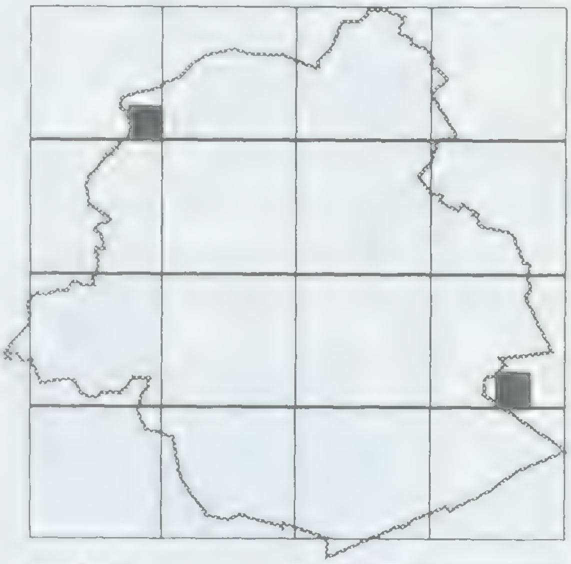
Map 138 Hypnum cupressiforme



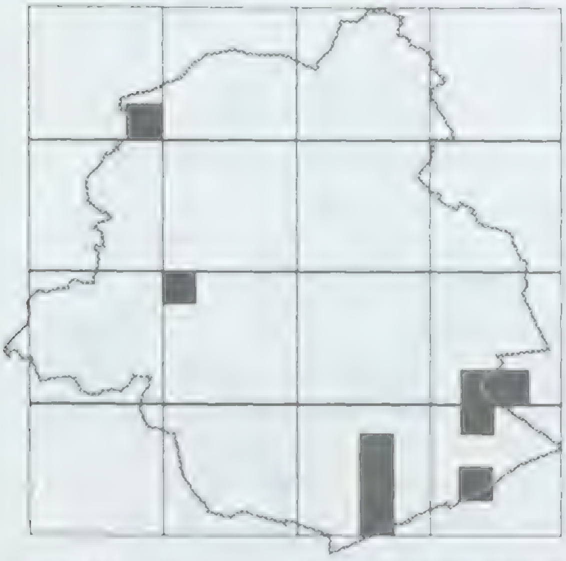
Map 139 Hypnum jutlandicum



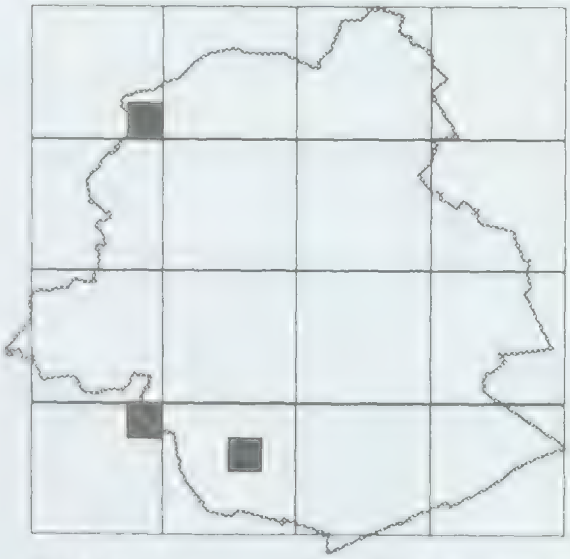
Map 140 Hypnum lindbergii



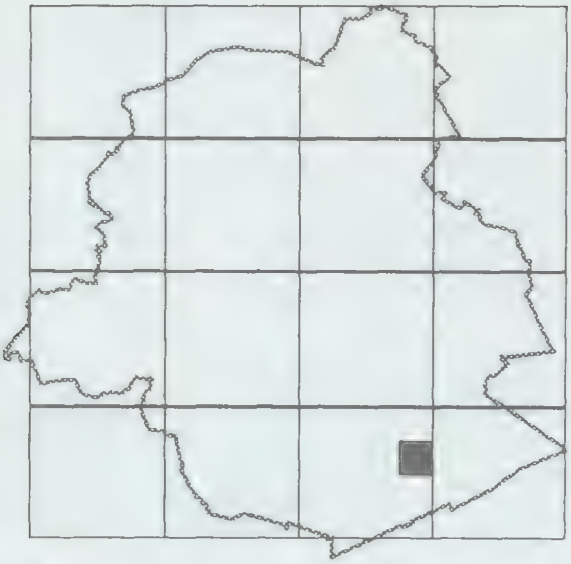
Map 141 Isothecium alopecuroides



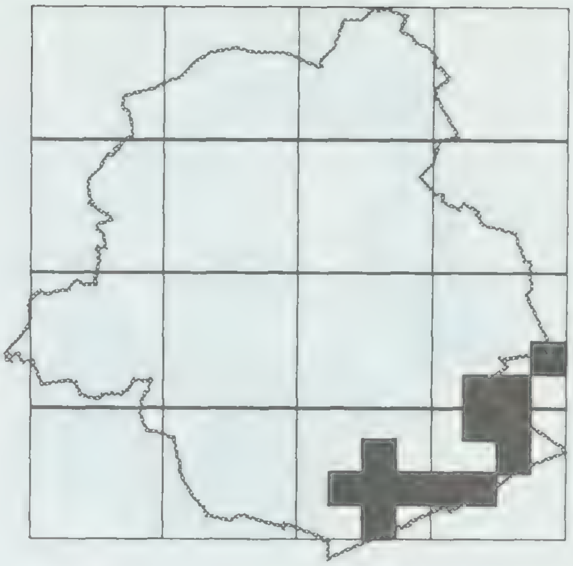
Map 142 Isothecium myosuroides



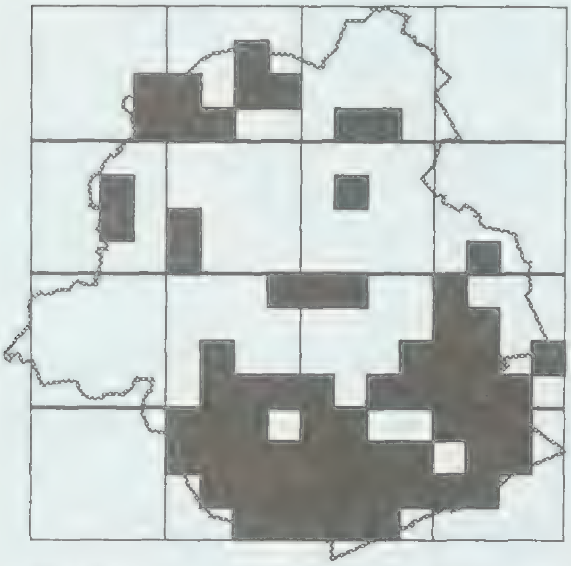
Map 143 Leptobryum pyriforme



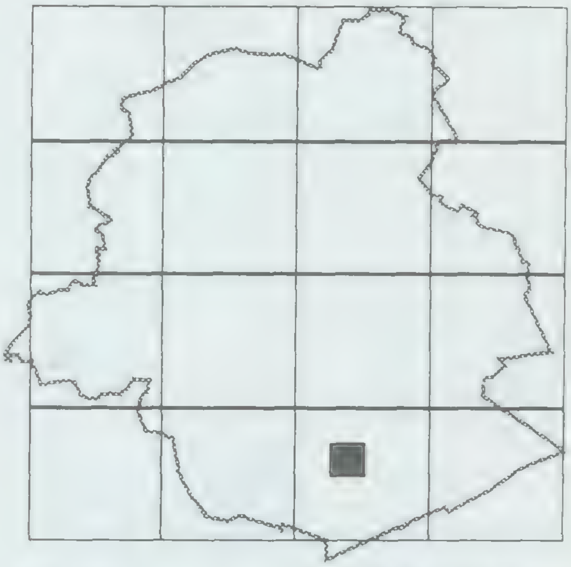
Map 144 Leskea polycarpa



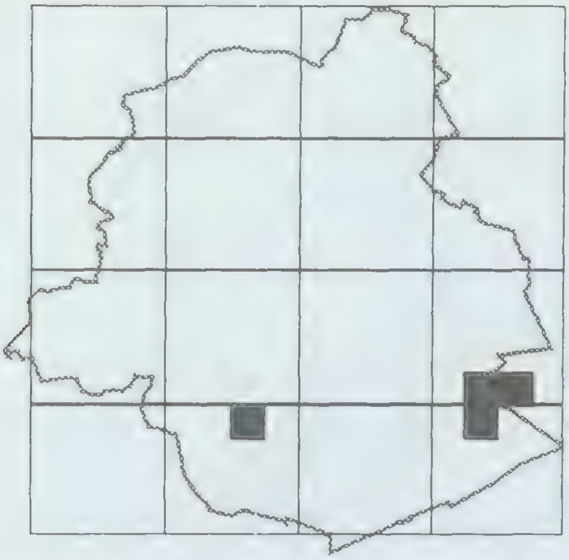
Map 145 Leucobryum glaucum



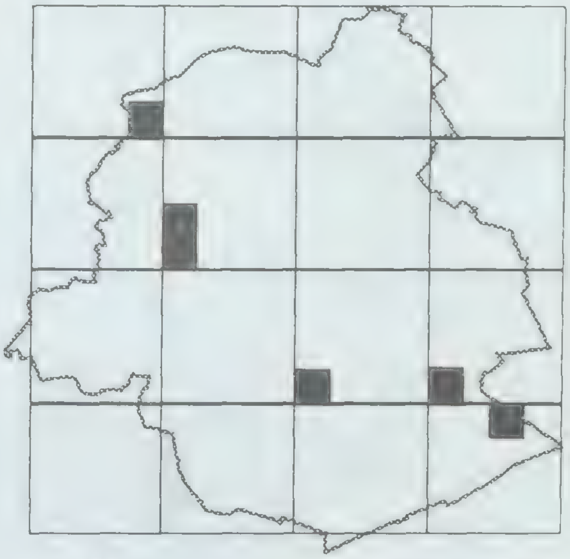
Map 146 Mnium hornum



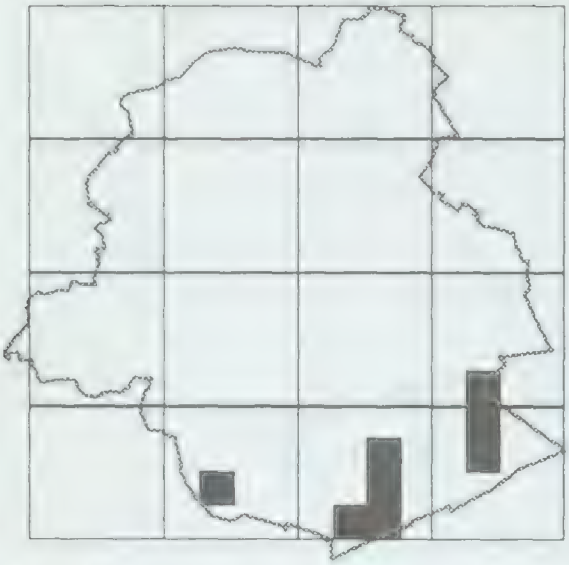
Map 147 Mnium marginatum



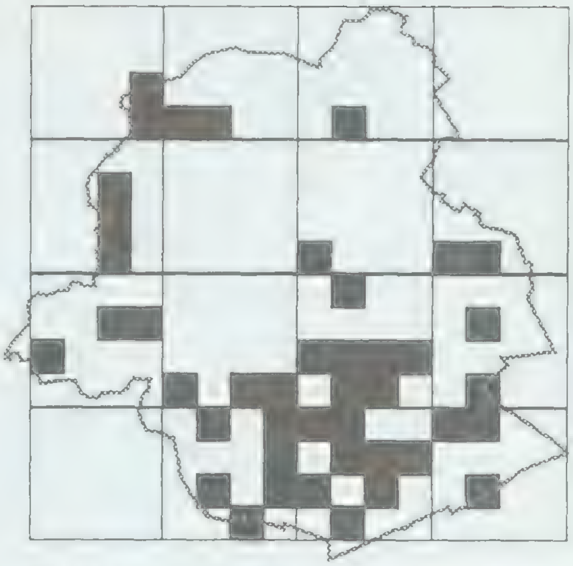
Map 148 Mnium stellare



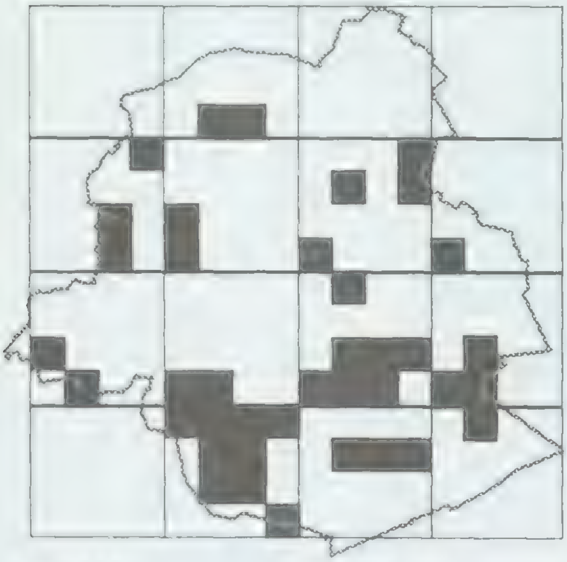
Map 149 Neckera complanata



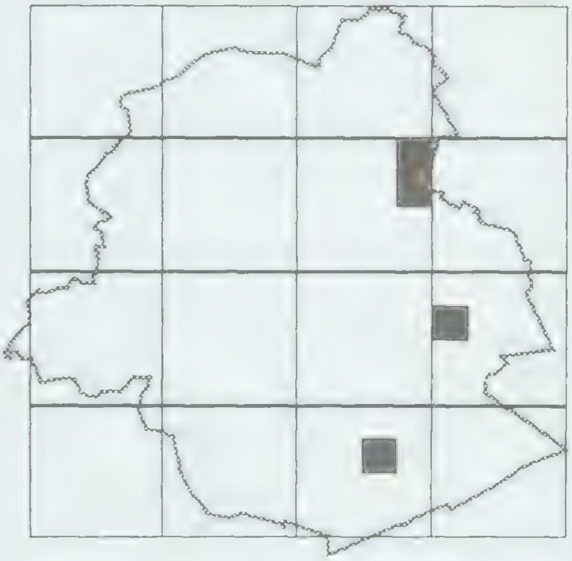
Map 150 Orthodontium lineare



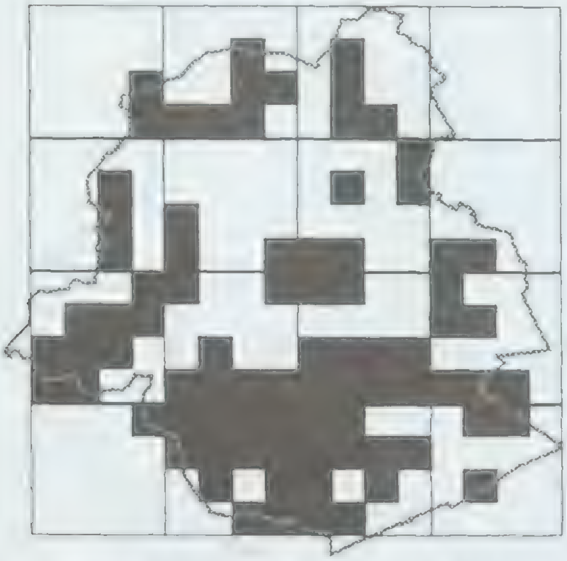
Map 151 Orthotrichum affine



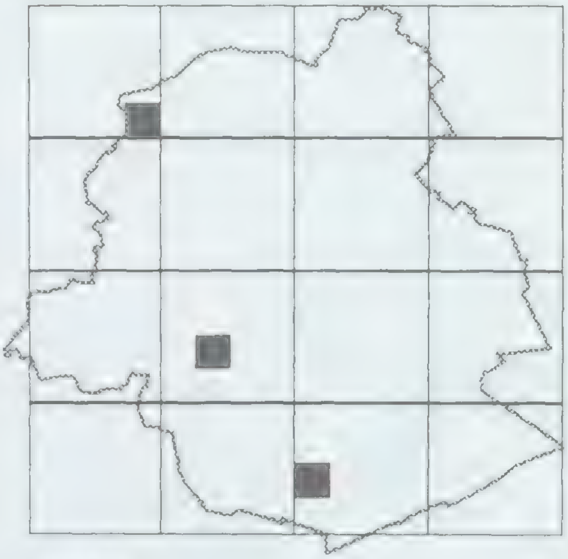
Map 152 Orthotrichum anomalum



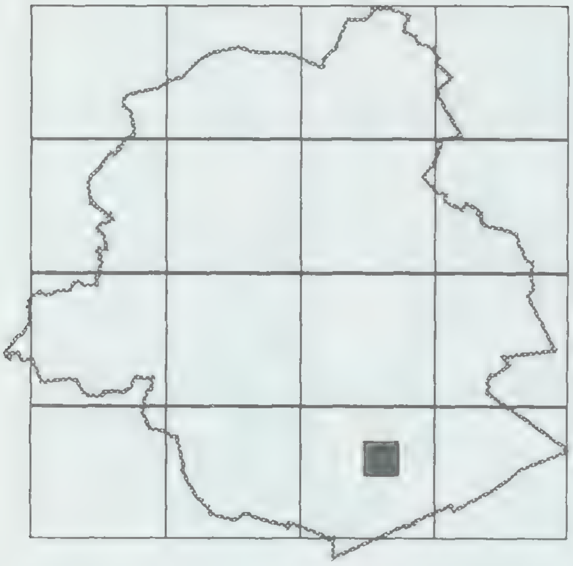
Map 153 Orthotrichum cupulatum



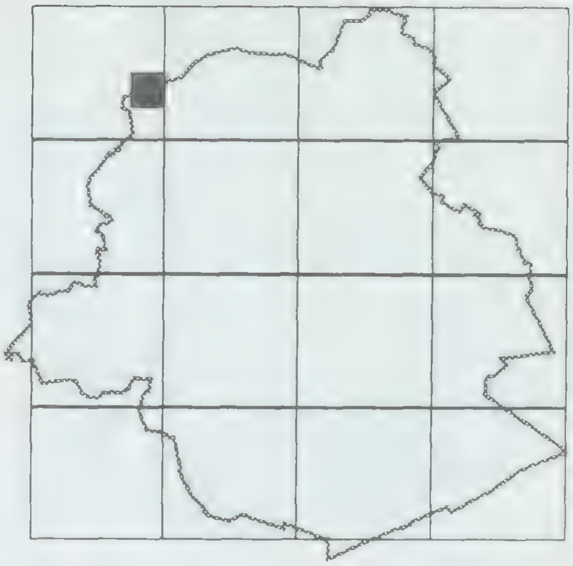
Map 154 Orthotrichum diaphanum



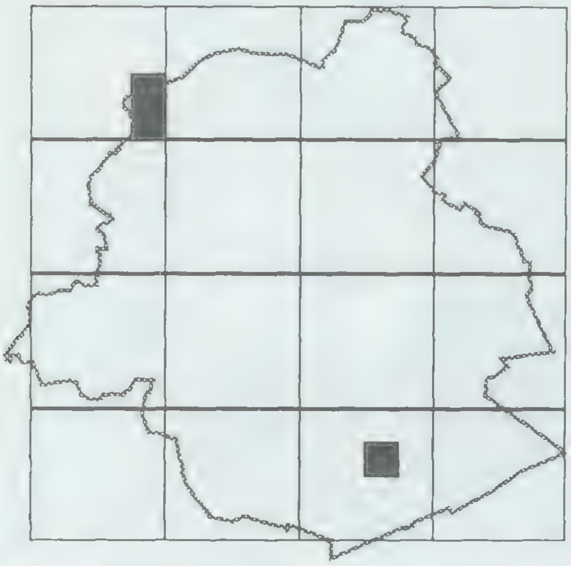
Map 155 Orthotrichum lyellii



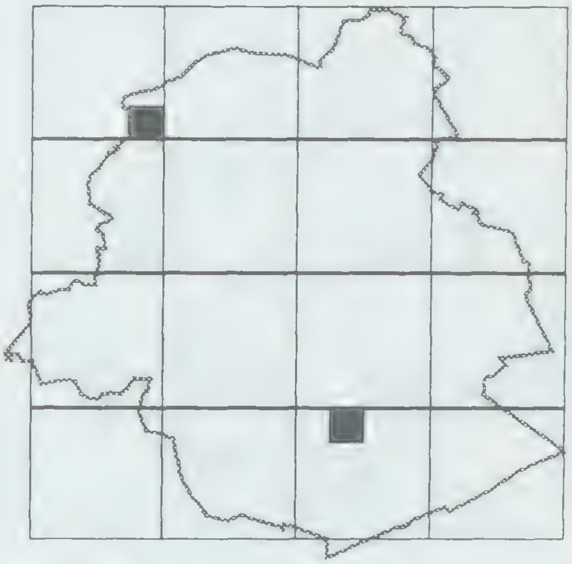
Map 156 Orthotrichum obtusifolium



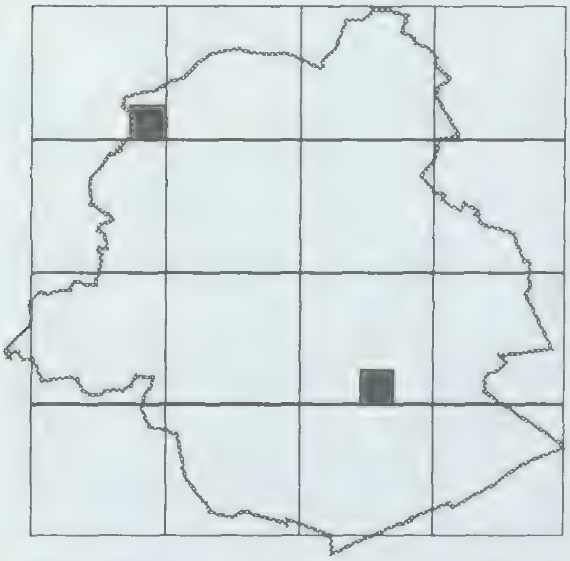
Map 157 Orthotrichum pallens



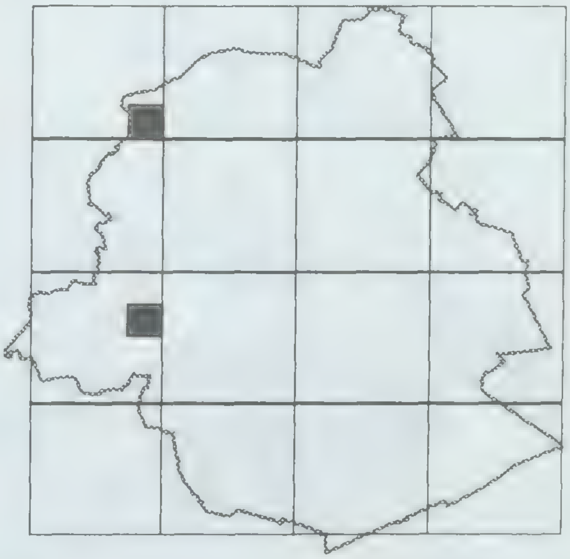
Map 158 Orthotrichum pulchellum



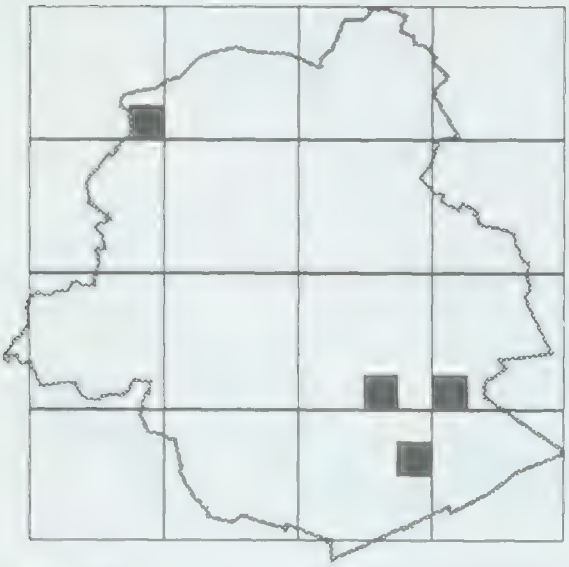
Map 159 Orthotrichum pumilum



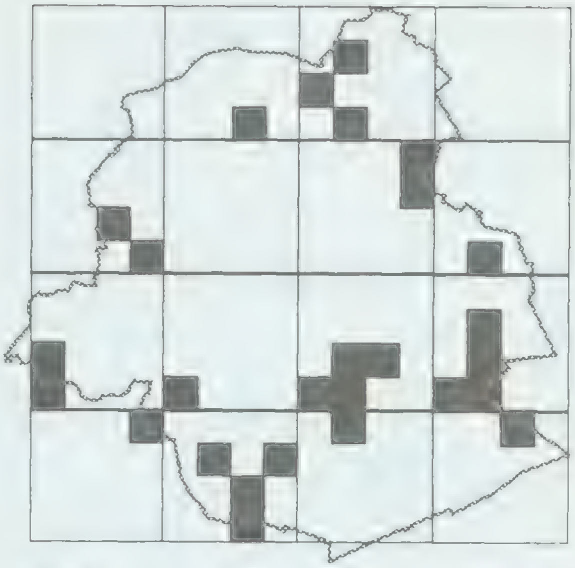
Map 160 Orthotrichum stramineum



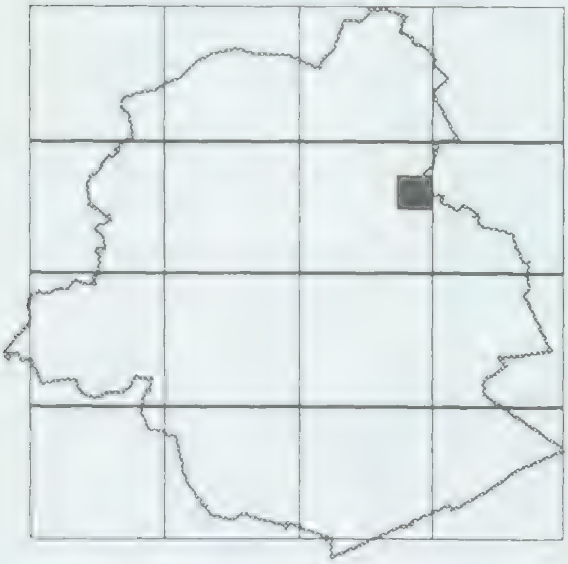
Map 161 Orthotrichum striatum



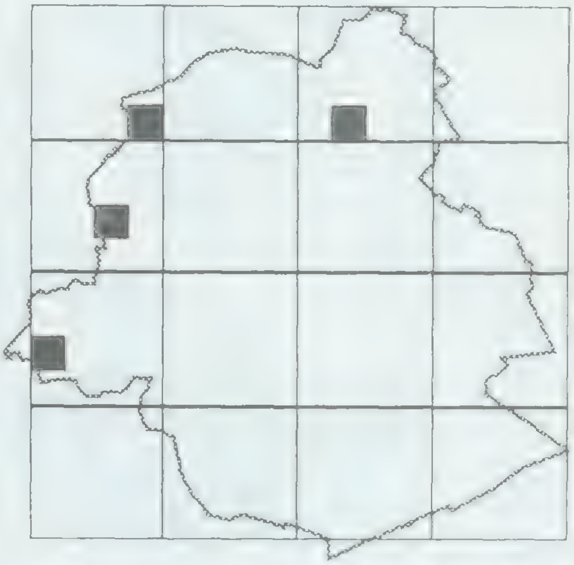
Map 162 Orthotrichum tenellum



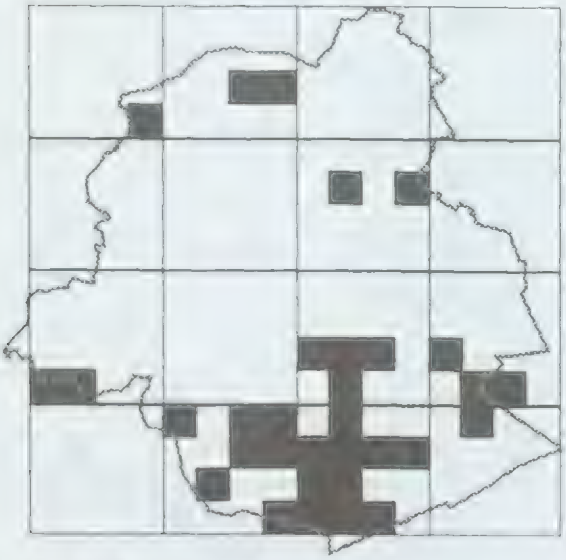
Map 163 Phascum cuspidatum



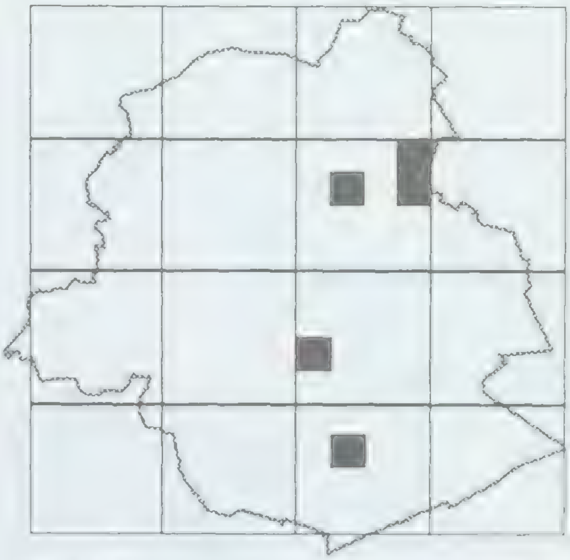
Map 164 Philonotis fontana



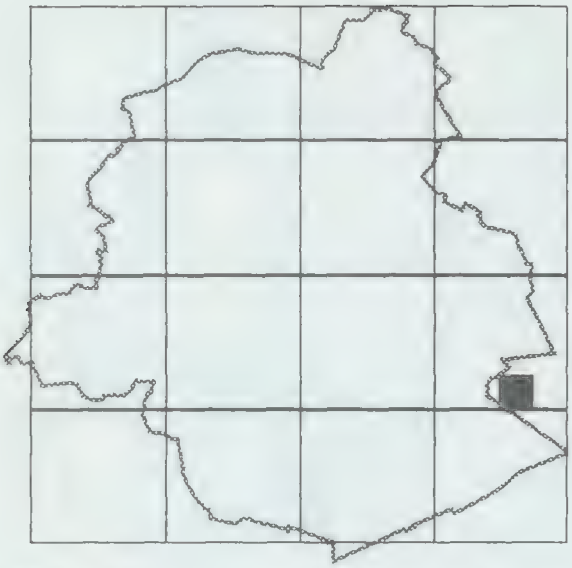
Map 165 Physcomitrium pyriforme



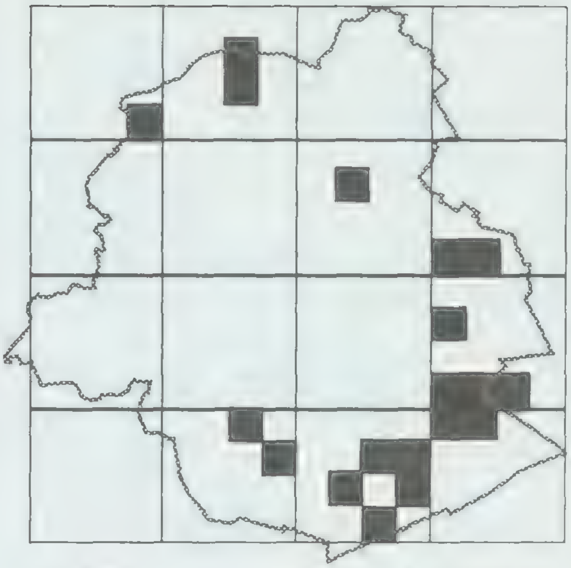
Map 166 Plagiomnium affine



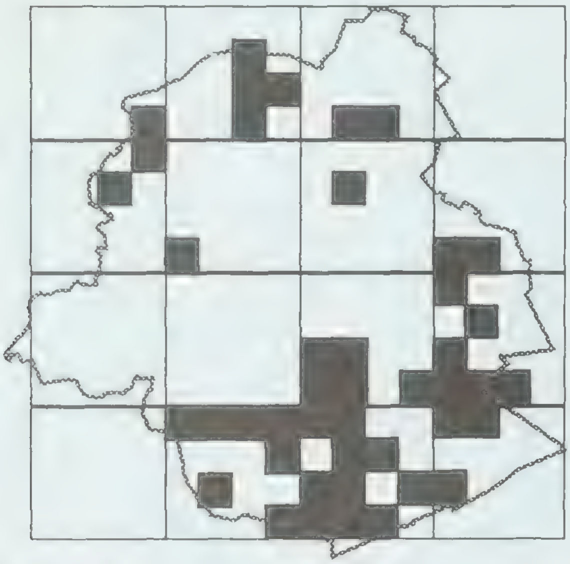
Map 167 Plagiomnium cuspidatum



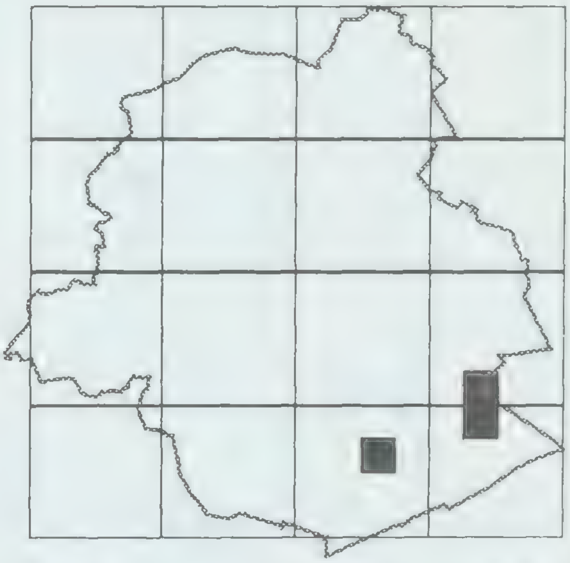
Map 168 Plagiomnium ellipticum



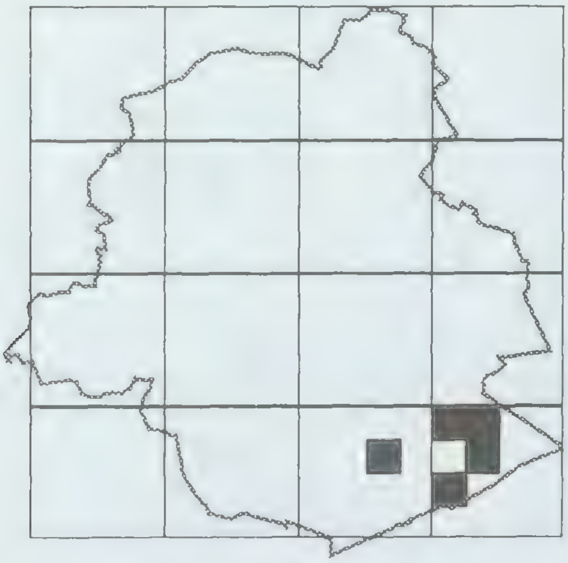
Map 169 Plagiomnium rostratum



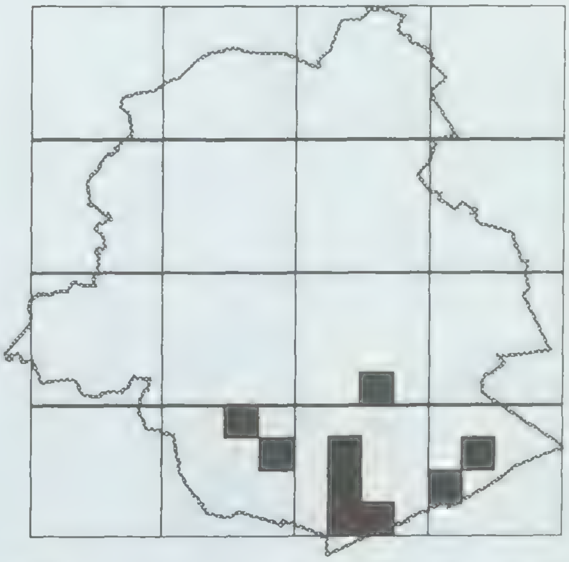
Map 170 Plagiomnium undulatum



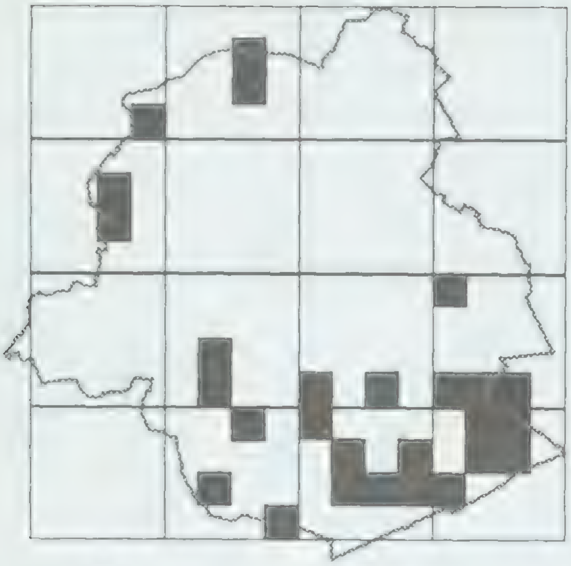
Map 171 Plagiothecium cavifolium



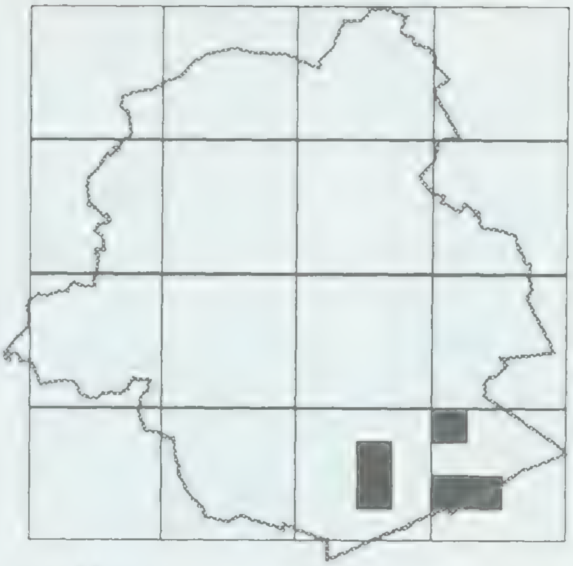
Map 172 Plagiothecium curvifolium



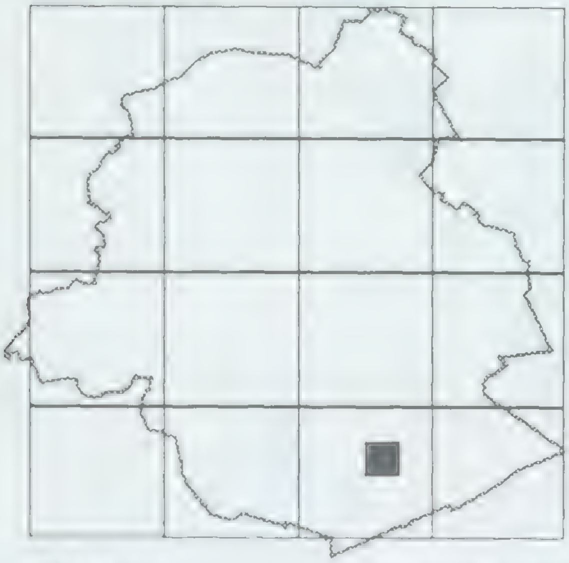
Map 173 Plagiothecium denticulatum



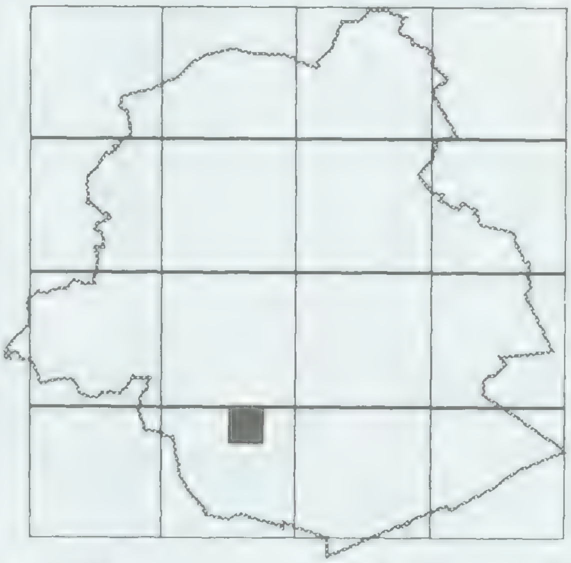
Map 174 Plagiothecium nemorale



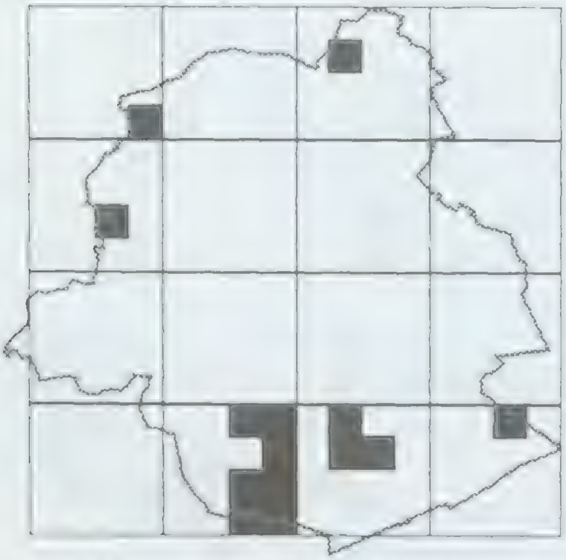
Map 175 Plagiothecium undulatum



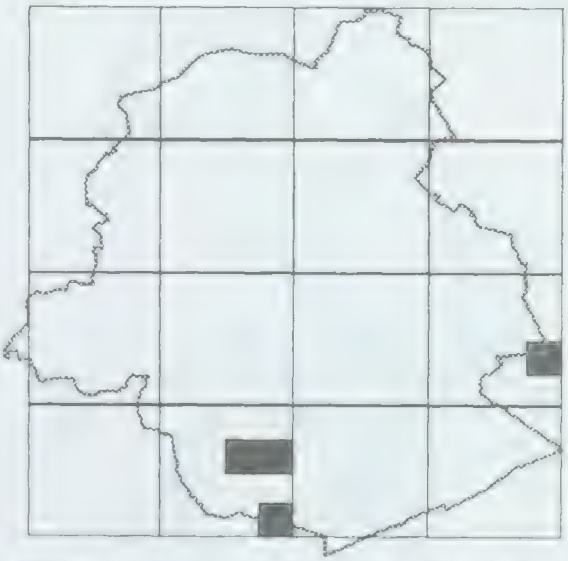
Map 176 Platygyrium repens



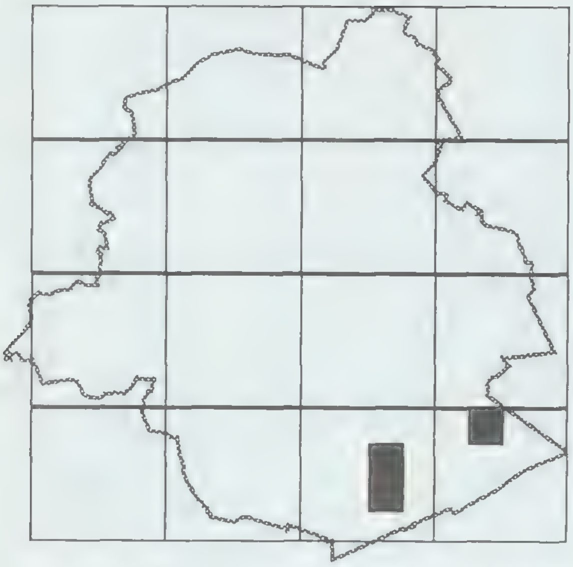
Map 177 Pleuridium acuminatum



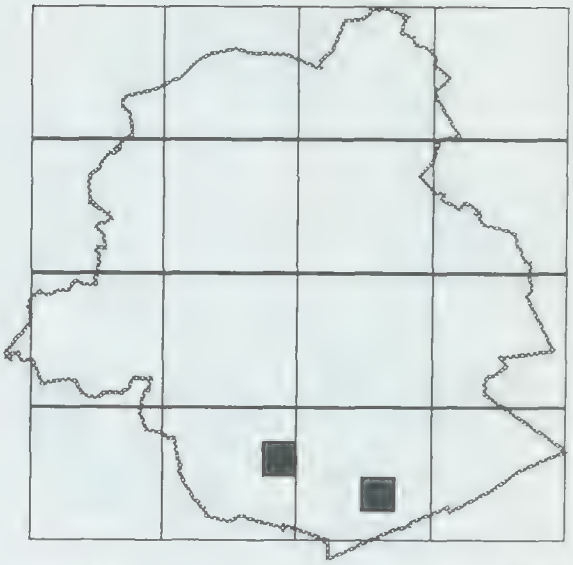
Map 178 Pleuridium subulatum



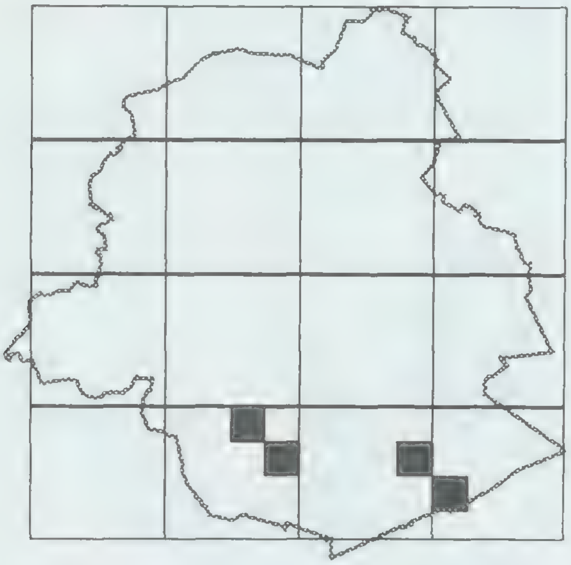
Map 179 Pleurozium schreberi



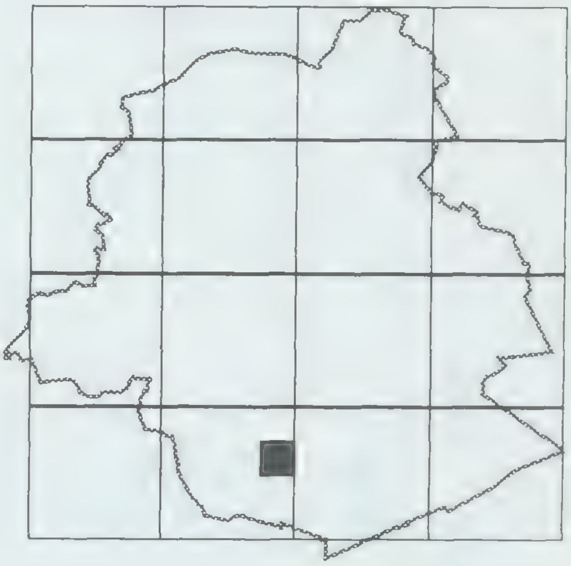
Map 180 Pogonatum aloides



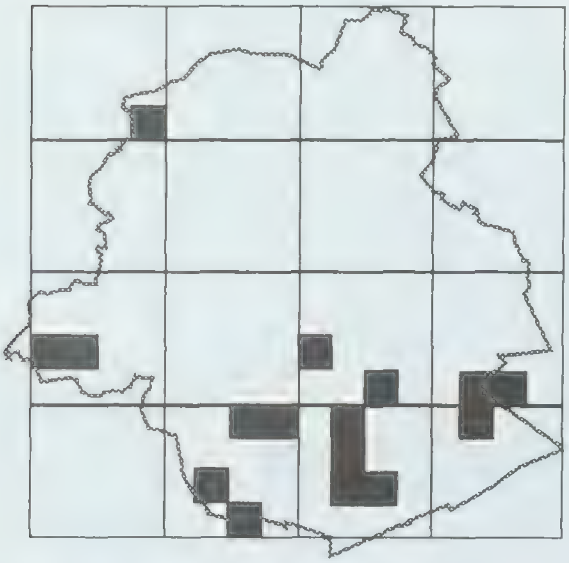
Map 181 Pogonatum nanum



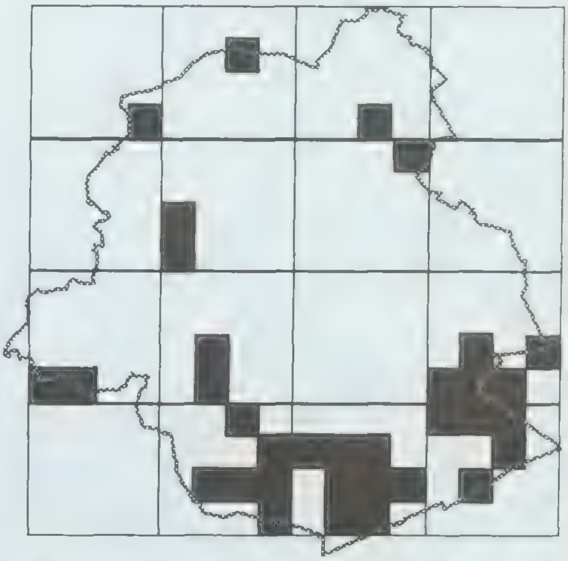
Map 182 Pohlia annotina



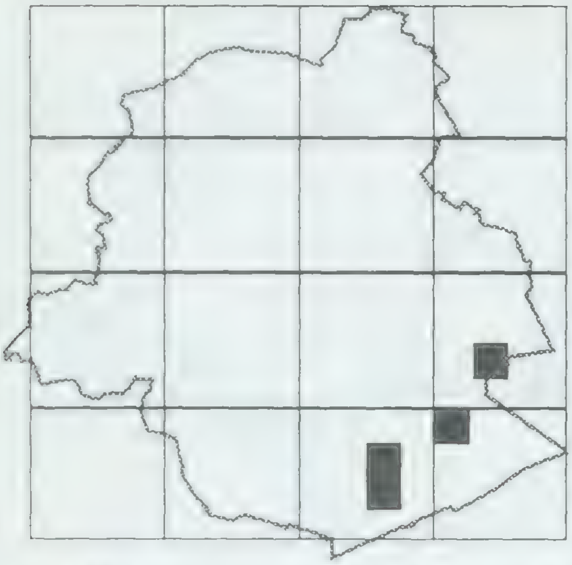
Map 183 Pohlia lutescens



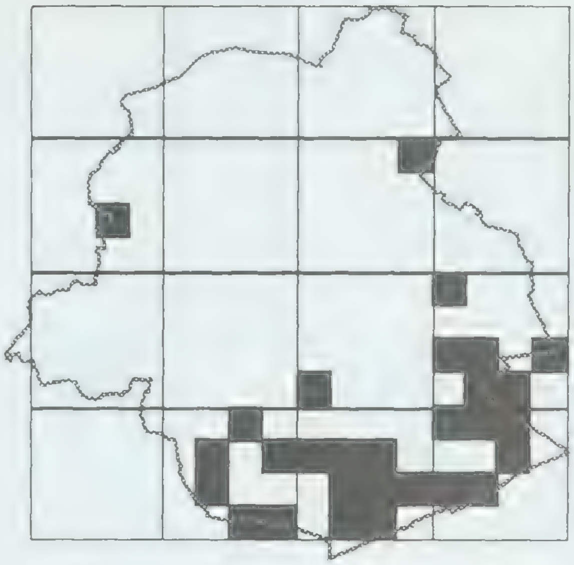
Map 184 Pohlia melanodon



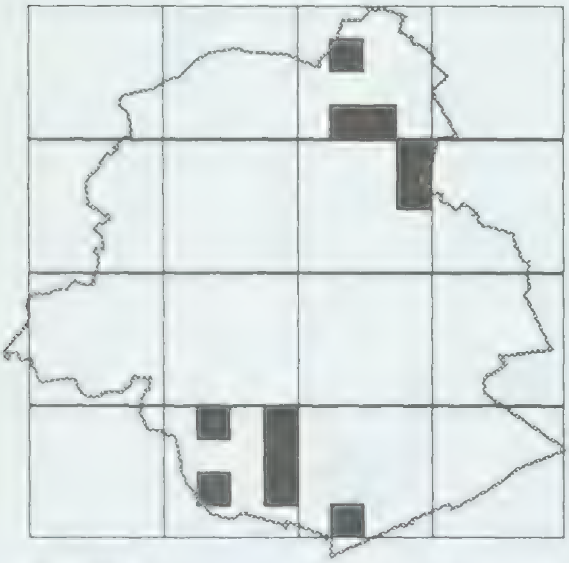
Map 185 Pohlia nutans



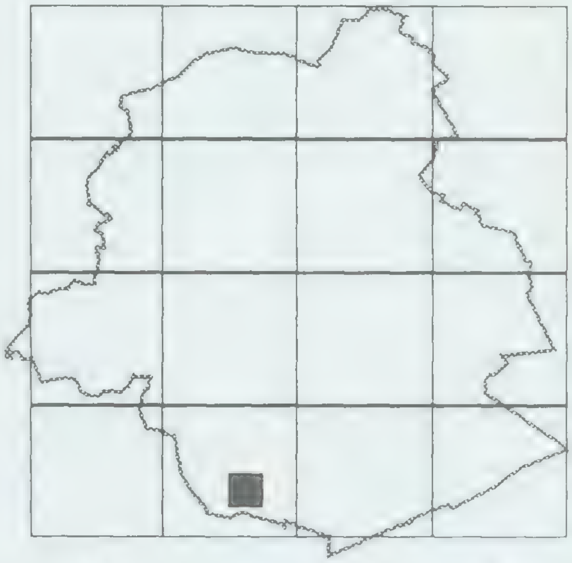
Map 186 Pohlia wahlenbergii



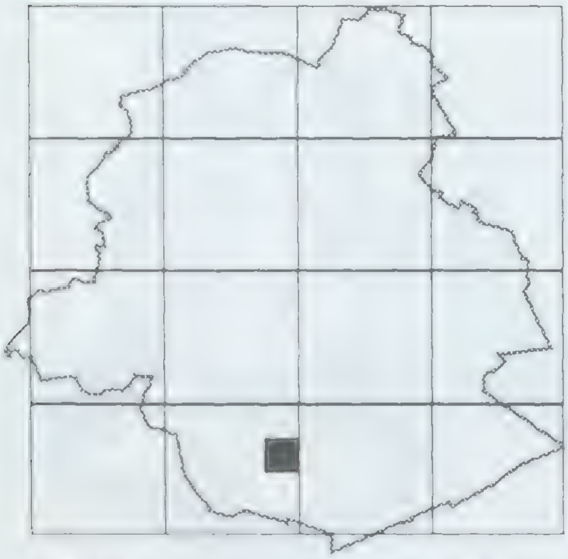
Map 187 Polytrichum formosum



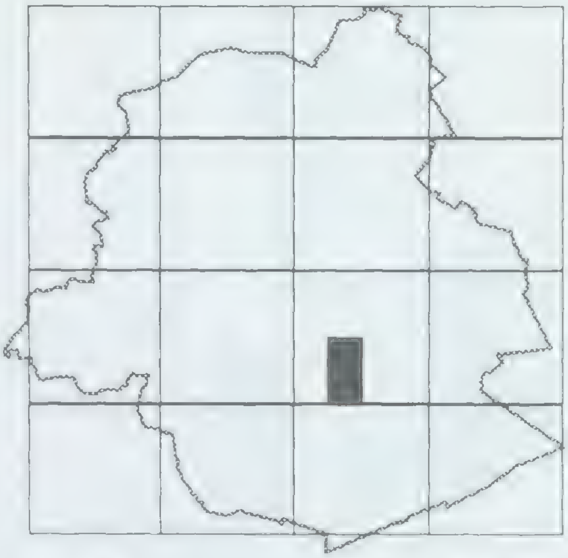
Map 188 Polytrichum juniperinum



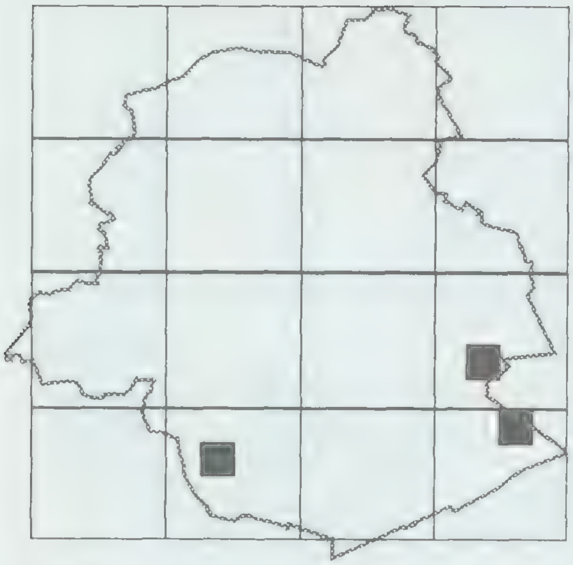
Map 189 Polytrichum piliferum



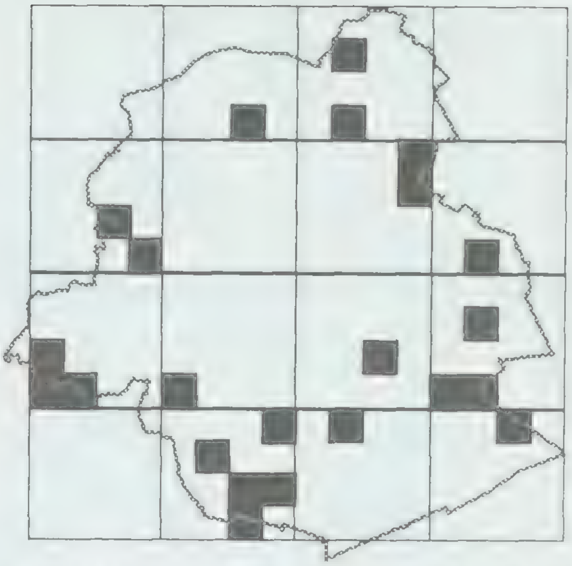
Map 190 Pottia bryoides



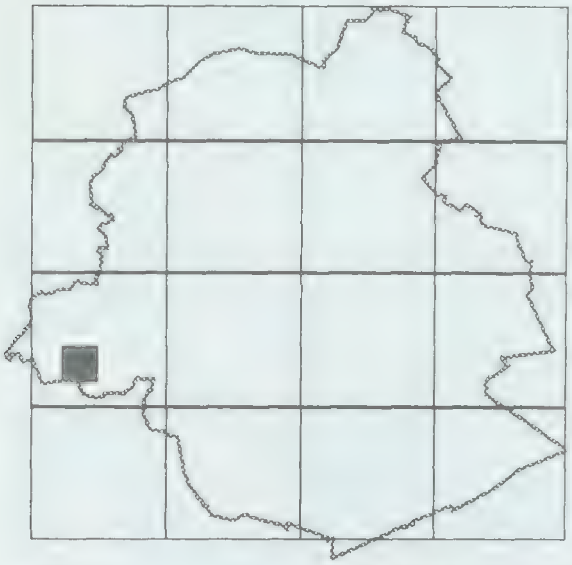
Map 191 Pottia davalliana



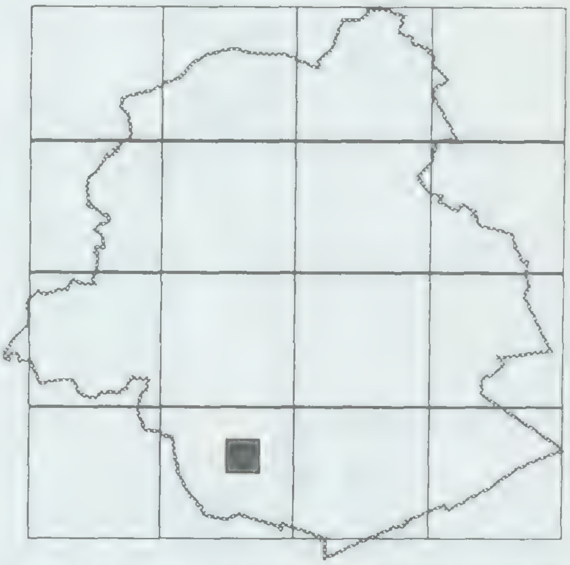
Map 192 Pottia intermedia



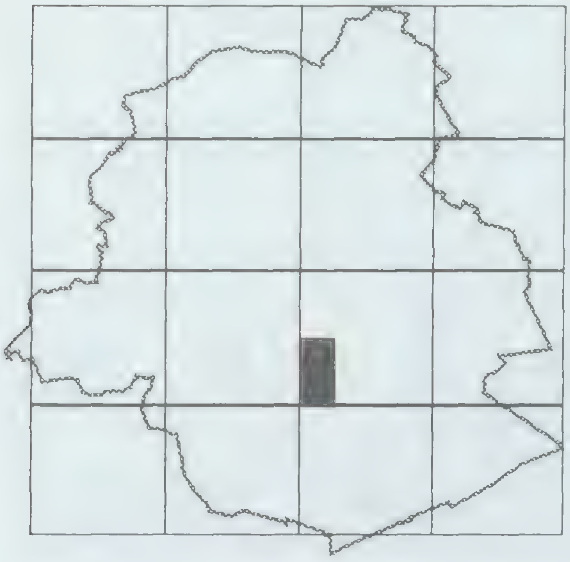
Map 193 Pottia truncata



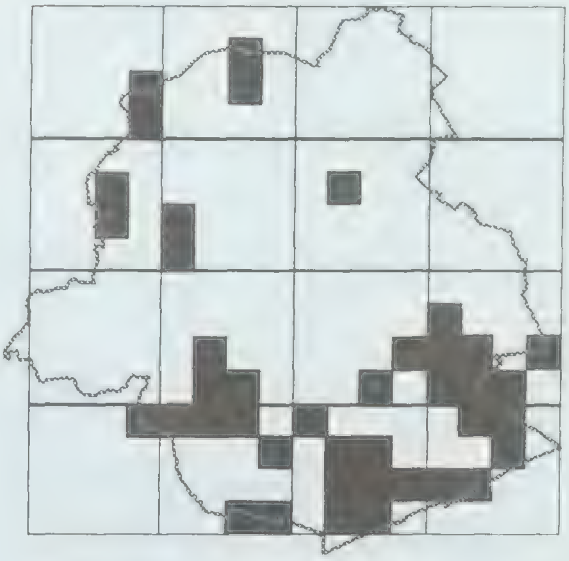
Map 194 Pseudephemerum nitidum



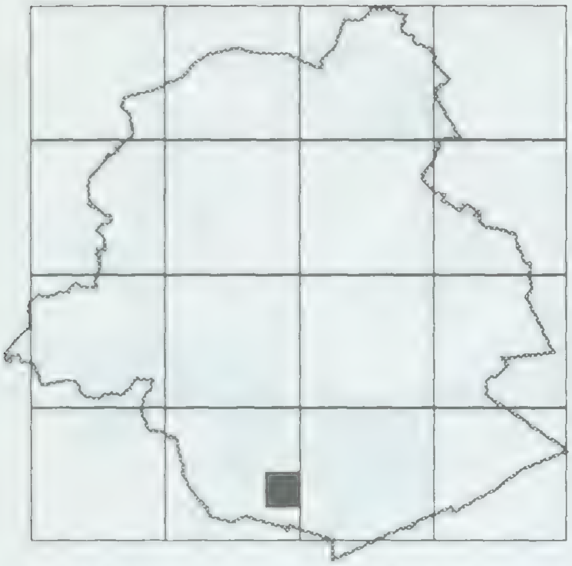
Map 195 Pseudocrossidium hornschuchianum



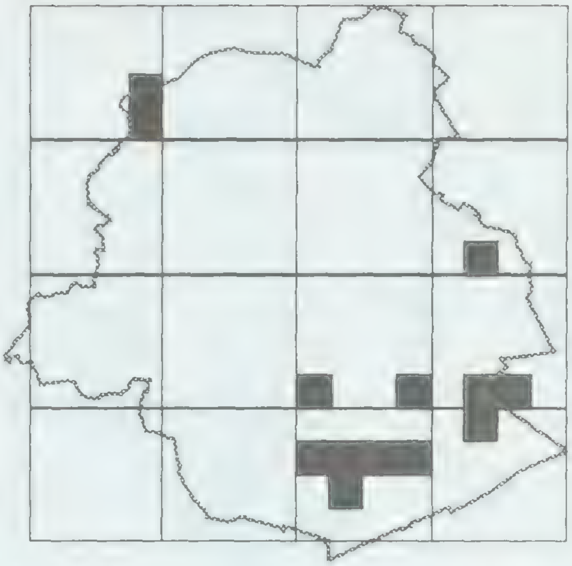
Map 196 Pseudocrossidium revolutum



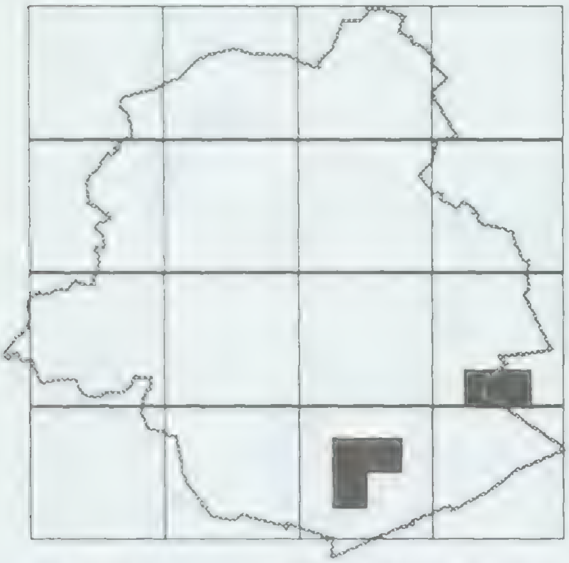
Map 197 Pseudotaxiphyllum elegans



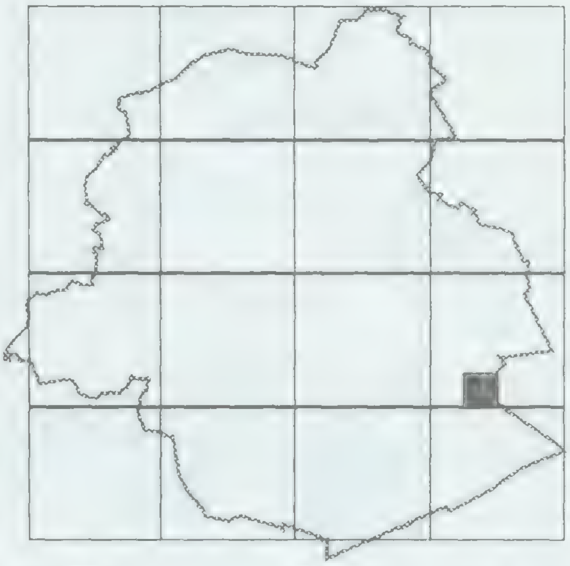
Map 198 Pylaisia polyantha



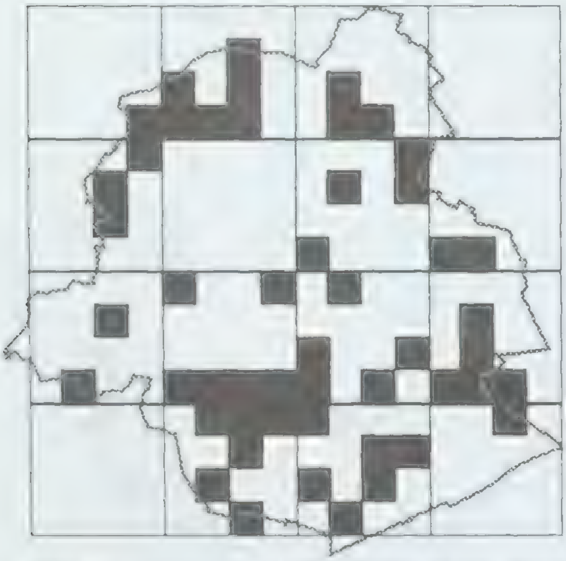
Map 199 Rhizomnium punctatum



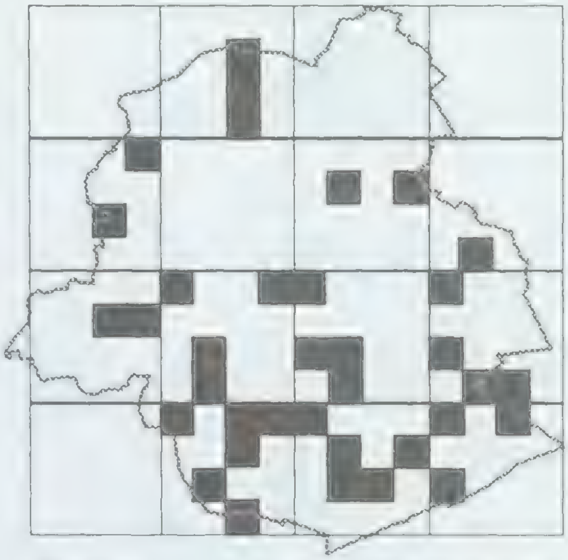
Map 200 Rhynchostegiella curviseta



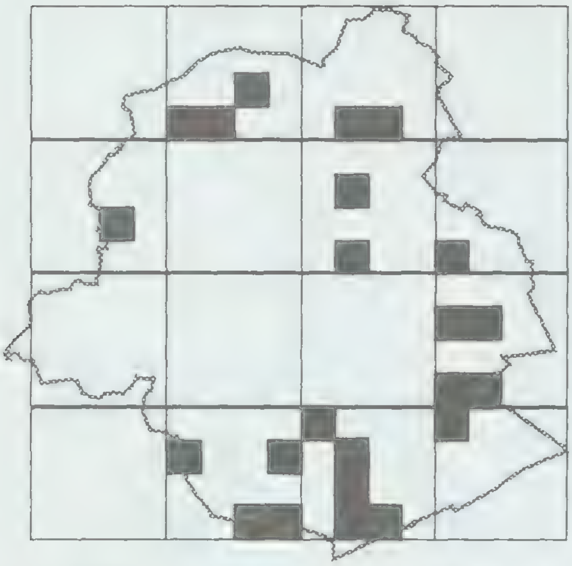
Map 201 Rhynchostegiella tenella



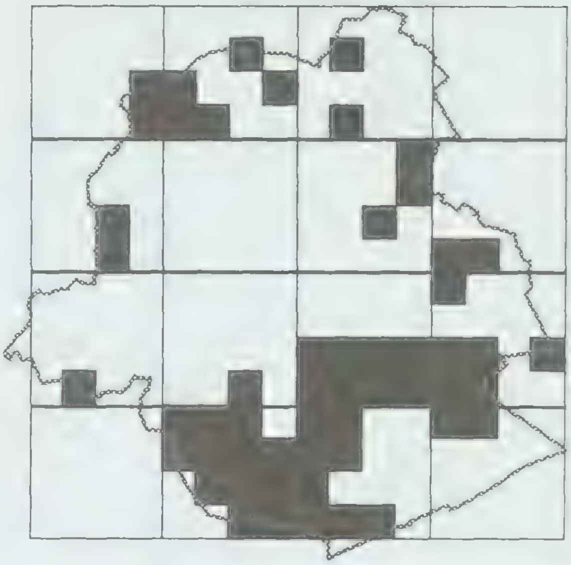
Map 202 Rhynchostegium confertum



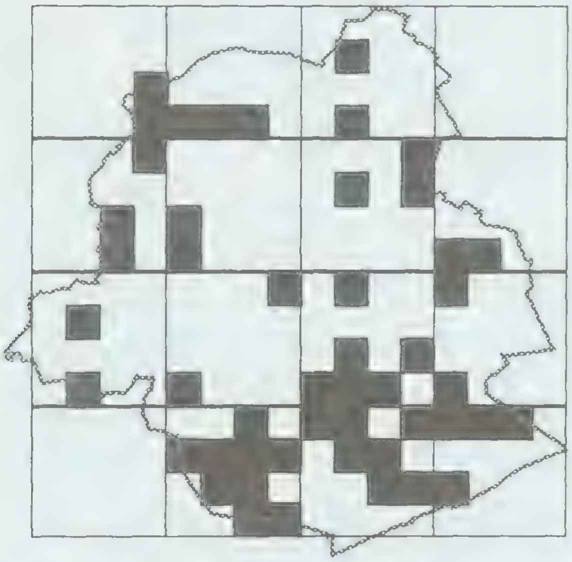
Map 203 Rhynchostegium murale



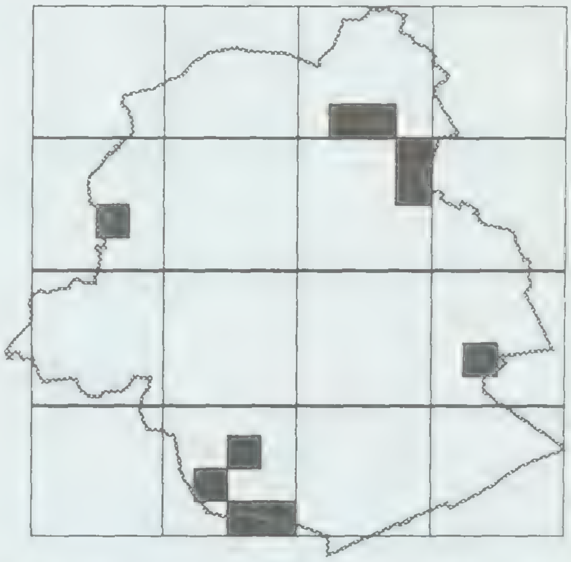
Map 204 Rhynchostegium riparioides



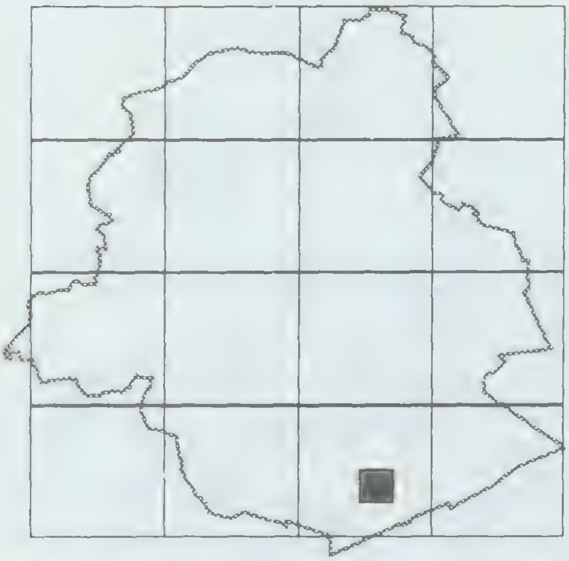
Map 205 Rhytidiadelphus squarrosus



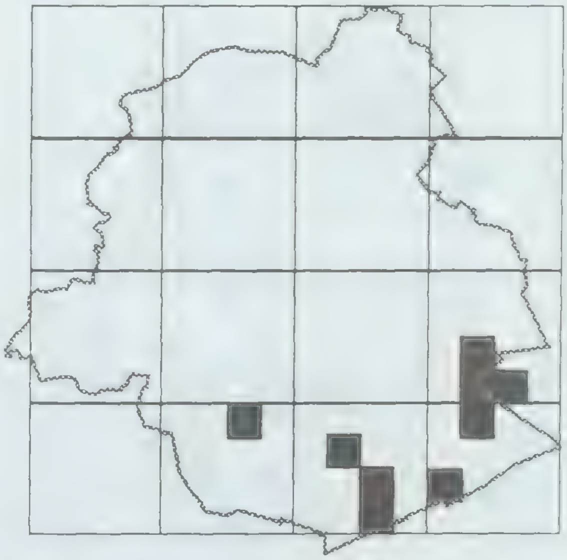
Map 206 Schistidium apocarpum



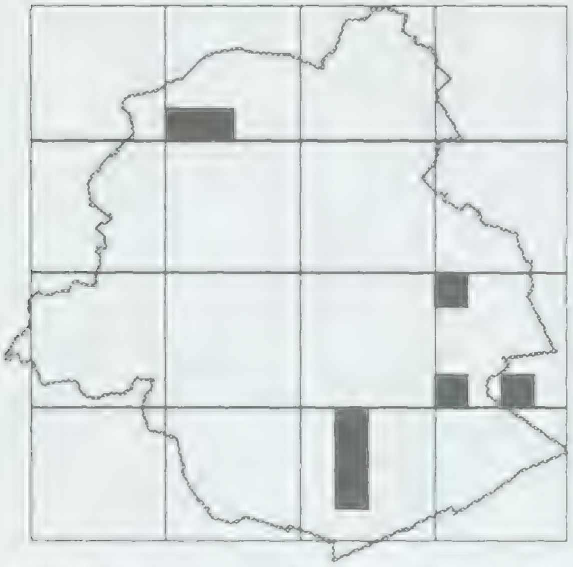
Map 207 Scleropodium purum



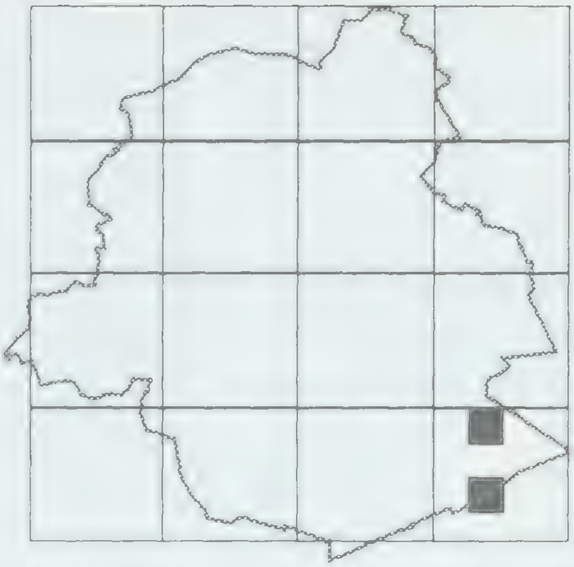
Map 208 Sphagnum flexuosum



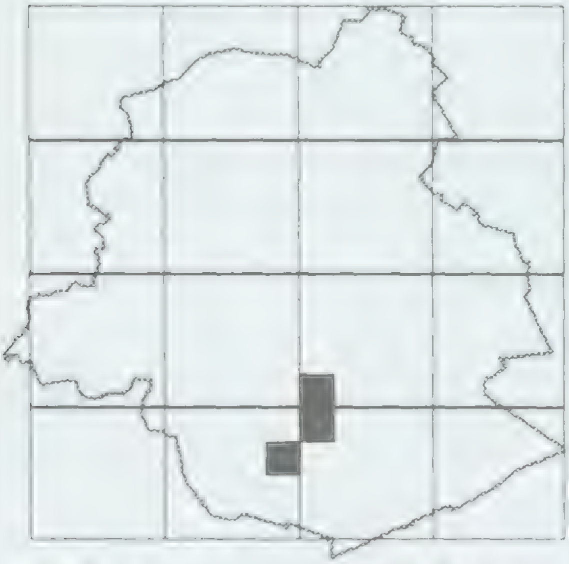
Map 209 Tetraphis pellucida



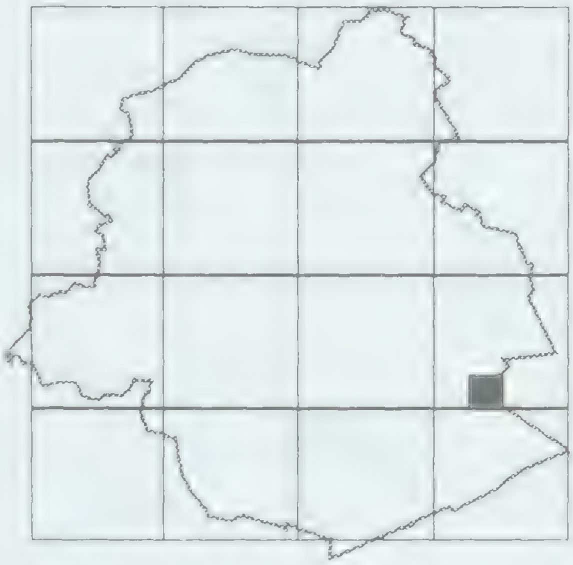
Map 210 Thamnobryum alopecurum



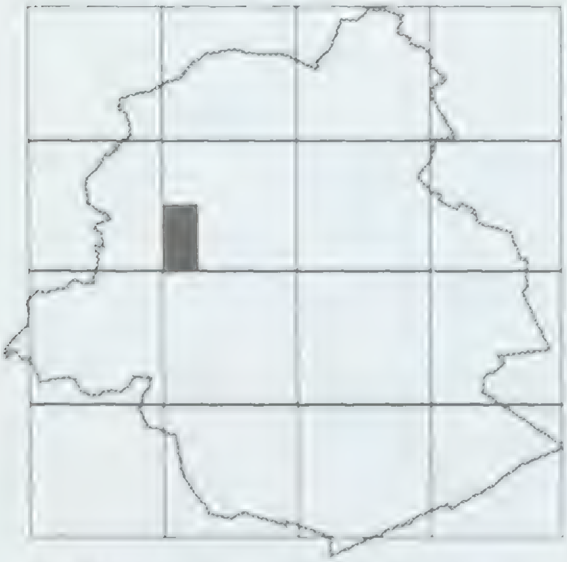
Map 211 Thuidium tamariscinum



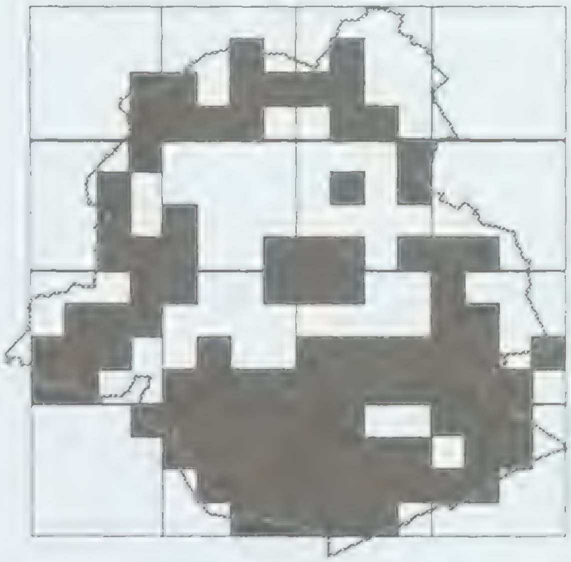
Map 212 Tortula truncata



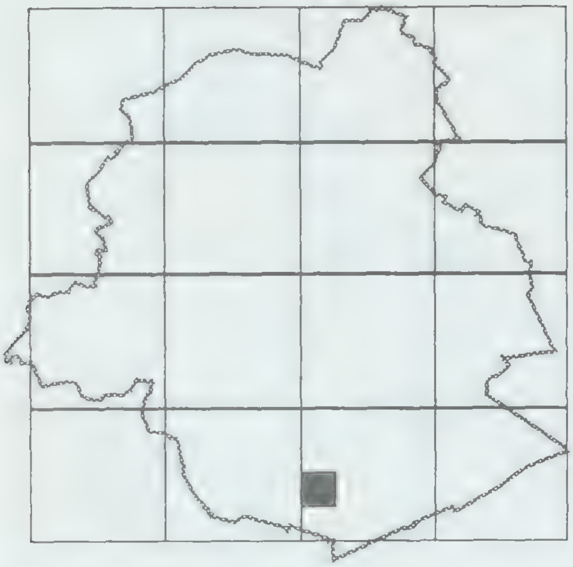
Map 213 Tortula intermedia



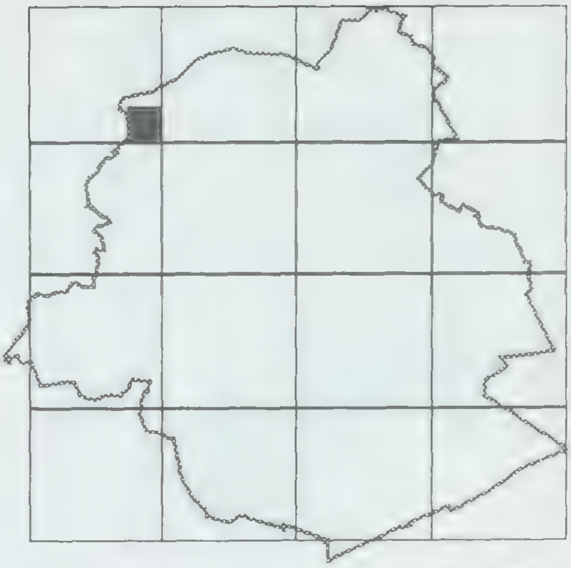
Map 214 Tortula lanceola



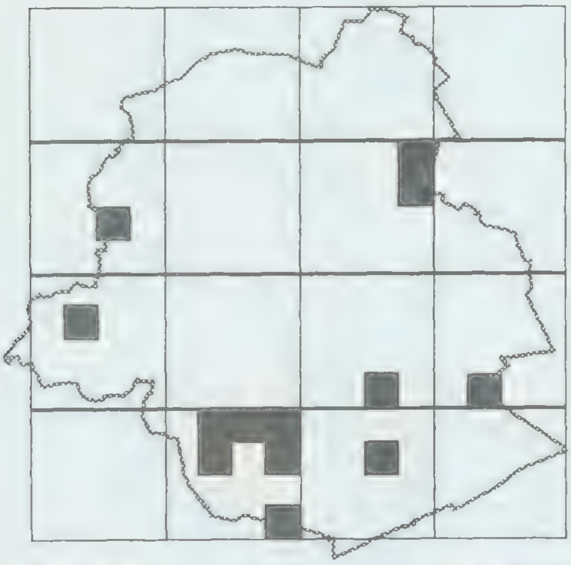
Map 215 Tortula muralis



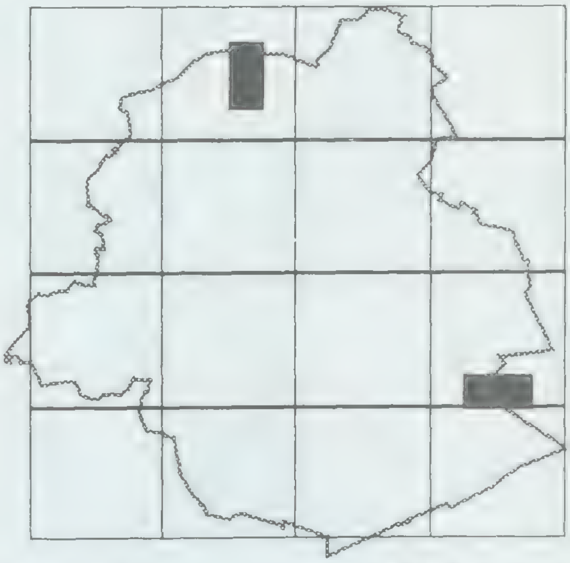
Map 216 Tortula pagorum



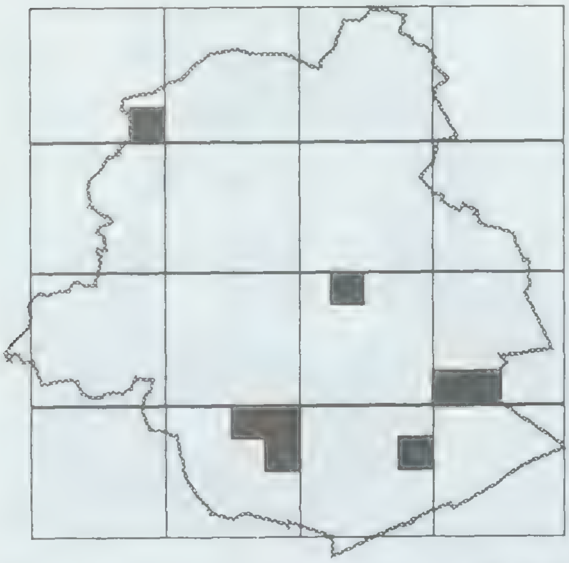
Map 217 Tortula papillosa



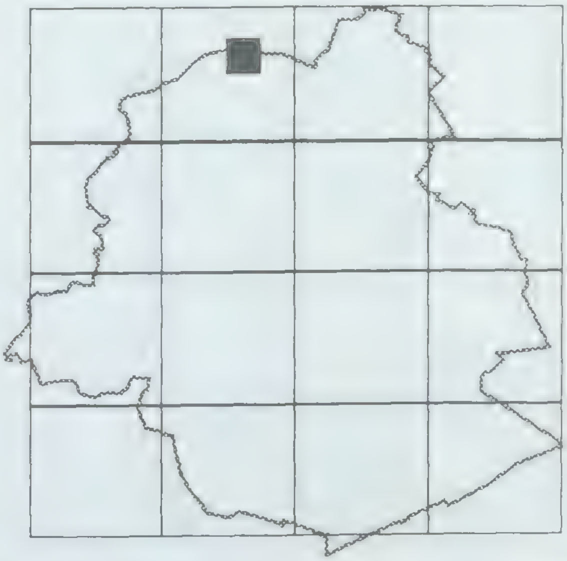
Map 218 Tortula ruralis



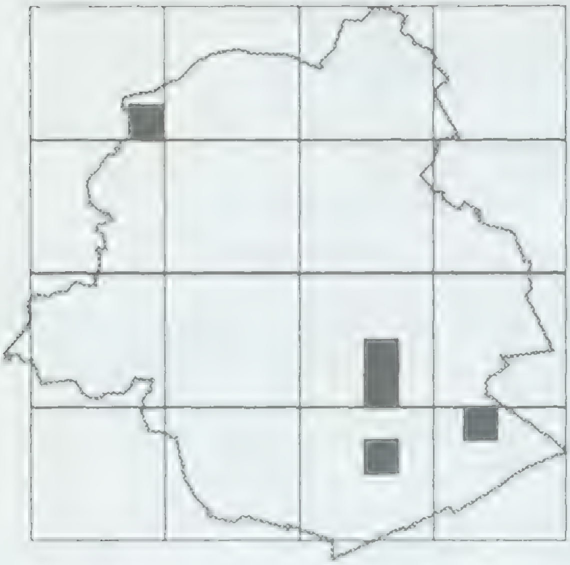
Map 219 Tortula subulata



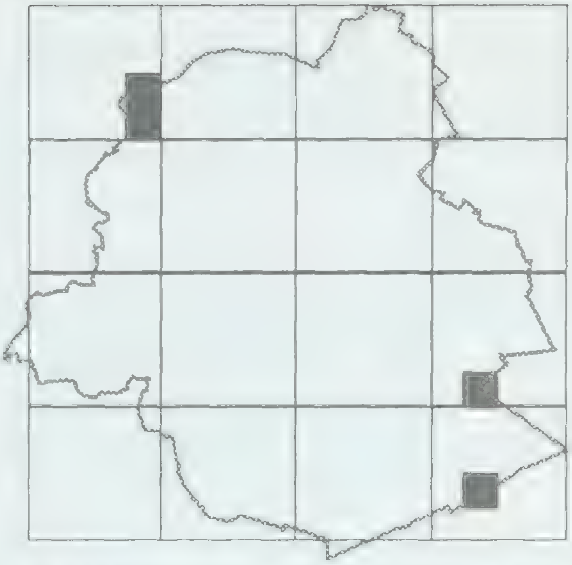
Map 220 Tortula virescens



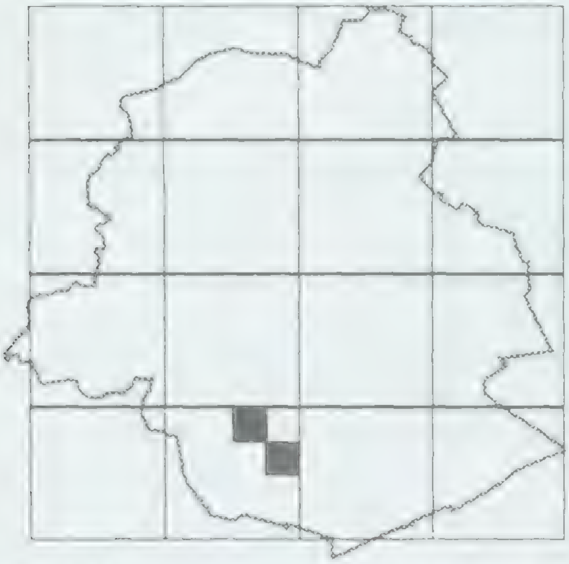
Map 221 Trichostomum crispulum



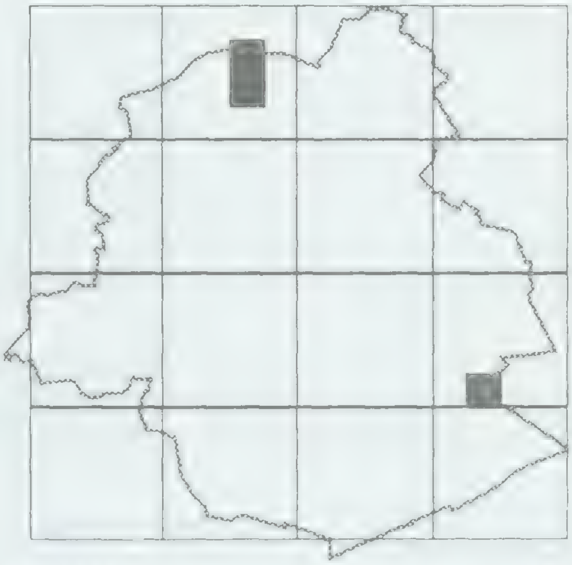
Map 222 Ulota bruchii



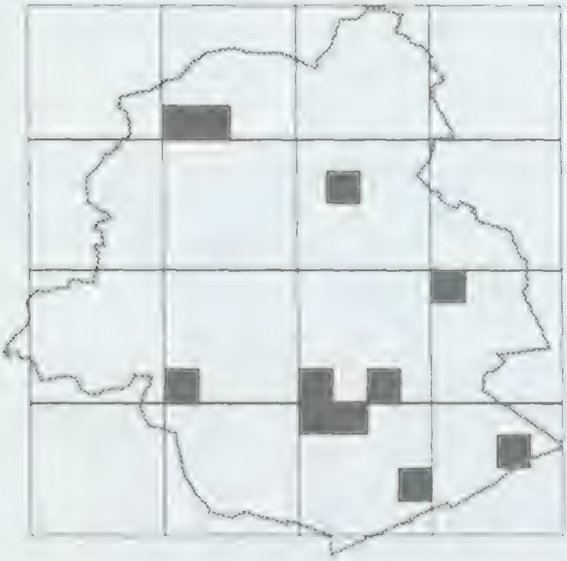
Map 223 Ulota crispa



Map 224 Weissia brachycarpa



Map 225 Weissia controversa



Map 226 Zygodon viridissimus

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Scripta Botanica Belgica Volume 14

A. Vanderpoorten

A bryological survey of the Brussels Capital Region (Belgium)

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This book has received the Emiel Van Rompaey award 1997. E. Van Rompaey (1896-1975) is famous for his pioneering floristic work in Belgium.

ISSN 0779-2387
ISBN 90-72619-36-6
D/1997/0325/7

0000400070146